April 1982

DMS-DR-2503

NASA-CR 167,363

RESULTS OF COMBINED LOADS ORBITER TEST (CLOT) IN THE NASA/LaRC 8-FOOT TPT USING THREE CONFIGURATION 20 TPS FLOW TEST PANELS (OS53A/B)

by

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Prepared under NASA Contract Number NAS9-16283

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WIND TUNNEL TEST SPECIFICS:

	20ACAL.PANEL	20A TEST PANEL	20C TEST PANEL
Test Number:	LaRC 8TPT 905	906,907	909
NASA Series Number:	OS53A	OS53A	OS53B
Model Number:	SSR717	SSR717	SSR719
Test Dates:	12-5-80 to 1-7-81	1-18-81 to 1-30-81	3-23-81 to 4-9-81
Occupancy Hours:	400	244	220

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ABSTRACT

This report contains post-test information for Combined Loads Orbiter Test (CLOT) OS53A/B which was conducted in the NASA/Langley 8-foot TPT from December 5, 1980 to April 9, 1981. Three full-scale panels representing actual Orbiter structure and Thermal Protection System (TPS) tiles near the Orbiter/ET attach structure (bipod), were tested under a simulated flight-time history profile.

Specific objectives of the test were threefold:

1) Verify that tiles remain attached to flight structure under simulated ascent conditions;

2) Compare measured and predicted tile and SIP (Strain Isolation Pad) loads (static and fluctuating pressures) and tile responses; and

3) Determine tile roughness characteristics after single and repeated ascent missions.

To meet these objectives, LaRC modified the 8-foot TPT facility to achieve a local simulation of the real time STS-1 and design launch profile in

ABSTRACT (Concluded)

the two regions represented by panels 20A and 20C. Mach numbers and dynamic pressure levels for the STS-1 trajectory simulation were varied from 0.6 to 1.1 and 400 to 750 psf, respectively. Design limit trajectory simulation Mach numbers and Q's were 0.6 to 1.1 and 480 to 900 psf, respectively. In addition to the above simulation, a hydraulic shaker system was installed in the tunnel to provide the STS-1 and design trajectory low frequency spectrum to the panel structure for test panel 20A only.

The 20A test panel was subjected to a total of 100 ascent cycles (25 missions), during which time no tiles were lost. There was no tile degradation through STS-1 (4 ascent cycles), but some tile sidewall erosion and adjacent OML chipping occurred during life cycling.

The 20C test panel was subjected to 144 cycles (36 missions). No tiles were lost or degraded through STS-1 and life cycling, but some fraying of the thermal barrier occurred after the equivalent of 16 missions.

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INTRODUCTION

This report presents post-test information for Combined Loads Orbiter Test (CLOT) OS53A/B which was conducted in the NASA/Langley Research Center's 8-foot TPT from December 5, 1980 to April 9, 1981. Three full-scale panels (one calibration panel and two test panels), representing actual Orbiter structure and Thermal Protection System (TPS) tiles aft (Configuration 20A) and forward (Configuration 20C) of the Orbiter External Tank attach structure (bipod), were tested under a simulated flight-time history profile.

CLOT was part of the overall TPS Flow Test Program and was originated as a direct result of the Williams Committee TPS review. This committee recommended that a combined loads test be run on representative TPS/substrate panels whose ascent loading conditions could jeopardize the success of STS-1.

Detailed test objectives were as follows:

1. Verify that tiles remain attached to flight structure under simulated ascent conditions.

2. Compare measured and predicted tile and SIP (Strain isolation pad) loads and responses:

   a) Compare measured and predicted loads by

      1) Static pressures on the overall panel, tile OML, filler bar, top of gap, SIP, and tile internal.

2) Fluctuating pressures on the overall panel, tile OML, filler bar, SIP, and tile internal.

B) Compare measured and predicted overall panel and tile responses by

1) Panel acceleration, static deflection, and location
2) Tile accelerations
3) SIP loads
4) Tile/substrate relative displacements

C) Evaluate load combination techniques

D) Determine changes in dynamic response characteristics under repeated loadings

3. Determine tile roughness characteristics (step and gap) after single and repeated ascent missions.

Before tests were run on the calibration and test panels, a satisfactory simulation of the flight environment was obtained by modifying the 8-foot TPT test section, as described in reference 10. These modifications were the result of previous subscale tests in Diffuser Flow Apparatus (DFA).

Other subjects covered in this report are model construction details, instrumentation, test procedures, test conditions, data reduction, and a description of the test facility. There are no formal data contained in this report. Rather, several preliminary hand plots of test data have been presented for general information only.

NOMENCLATURE

SYMBOL	DESCRIPTION
ACD	Analysis and Computation Division at Langley
ARC	Ames RESEARCH Center
CPS	Cycles per second
$C_{p\infty}$	Freestream static pressure coefficient
DFA	Diffuser Flow Apparatus
dB	Decibles, psi
DFI	Development Flight Instrumentation
ET	External Tank
ESP	Electronically Scanned Pressure
grms	Root mean square gravity force
Hz	Cycles per second
IML	Inner Mold Line
K	Surface roughness, inches x 10^{+3}
LaRC	Langley Research Center
M_∞	Freestream Mach Number
M_L	Local Mach number
OML	Outer Mold Line
P_{SIP}	Pressure measured in SIP, psia
PCF	Pounds per cubic foot
P_L	Local pressure, psia
q_L, Q_L	Local dynamic pressure, psi
Q.C.	Quality Control
RTD	Resistance Temperature Device

NOMENCLATURE (Concluded)

SYMBOL	DESCRIPTION
SIP	Strain Isolation Pad
STGR	Stringer
TPS	Thermal Protection System
TPT	Transonic Pressure Tunnel
X	Longitudinal distance from front edge of panel, inches
X_o	Orbiter station, inches
Y	Lateral distance from $\mathcal{C}_L$ of panel, left is positive, inches
Y_o	Orbiter butt plane lateral distance, inches
Z	Vertical distance from panel IML (OML is in negative direction), inches
ΔP_{shock} $\Delta P_{bowshock}$	Differential pressure across shock, psi
σ	Stress, psi
ε	Strain, in/in
δ_L	Boundary layer thickness, in

DISCUSSION OF TEST RESULTS

Test Configuration 20A

The 20A test configuration was subjected to static air loads; local shocks; and structural, acoustic and vibration environments of the STS-1 launch trajectory profile.

Good simulation of the local STS-1 static environment was obtained for the lower Mach number simulation (Freestream Mach = 0.6 to 0.9). See figure 60a and b. Figure 60c shows that good simulation of the local dynamic pressure was obtained at the higher Mach numbers (Freestream Mach = 1.1 to 1.4); however, there were large deviations from the STS-1 static pressure levels with a correspondingly higher local pressure gradient in this region. (See figures 60d and e). Local Mach number simulation is depicted in figure 60f.

The acoustic environments depicted in figure 60g were closely simulated at local Mach numbers of M = 0.9 on the forward part of the panel, and at M = 1.2 in the center of the panel. Overall acoustic dB levels were comparable, but low frequency response on CLOT never peaked out as it did on IS-2. This is probably due to a thicker boundary layer on the CLOT full-scale model. (Reference 6).

Vibration levels over the frequency spectrum closely approximated the overall grms values that were experienced on FFA04 (Fwd. Fus. Under Body Panel). These values ranged from 20 grms to 33 grms for FFA04 while CLOT values were 25 grms to 38 grms.

No tiles were lost during the 25-mission (100 cycles) and no tiles were degraded during the first mission (4 cycles). During subsequent missions, there were tiles that incurred coating chips, due to tiles apparently bumping into one another. Tile surface roughness is indicated in figure 60h. A cumulative damage map of the 20A test panel is shown in figure 60i. Stress/strain diagrams for tile numbers 39, 50 and 51 are presented in figures 60j, k and l, respectively.

Test Configuration 20C

The STS-1 ascent trajectory profile static airloads, local shocks, and acoustic level environment were to be imposed on panel TC-20C test tiles. However, a one-half-scale bipod model was used because of tunnel instability with the larger bipod models. As a result, the primary parameter simulated was the maximum STS-1 acoustic level and time duration. The resultant static airloads environment is presented in figures 60m through x. Detailed discussions of these data can be found in reference 4.

Maximum acoustic levels were obtained through simulation of the pressure rise across the bowshock in front of the bipod. The test bowshock differential pressure curve is in close agreement with the STS-1 nominal trajectory curve. However, simulation of the local dynamic pressures and the local Mach numbers is only fair at the transonic Mach numbers with the test values deviating significantly from the STS-1 nominal trajectory curve at the higher supersonic Mach numbers. Local test pressure distributions from M_∞ = 0.6 to 1.4 show close agreement with the STS-1 nominal trajectory pressures, except immediately forward of the bipod where the test pressures are approximately 1.5 psia higher. Simulation of the local pressure distributions is poor at the maximum bowshock pressure rise conditions (M_∞ = 1.76). Estimated SIP pressures using the TPS tile loads math model (reference 4) are approximately 1.75 psia higher than the measured SIP pressures, indicating a lower test positive normal force on the tiles. The present design SIP pressure model of reference 4 is based on test results from other tests, and the results from the CLOT test do not exceed the design model loads.

Four STS-1 simulated missions (16 cycles) were completed on March 28 to flight-qualify test panel TC-20C for launch. An additional 32 life missions were completed using the same simulation. There was no degradation of the test tiles. A tile surface roughness comparison is shown in figure 60y.

CONFIGURATIONS INVESTIGATED

CLOT Program Background

The panels tested for the CLOT program were chosen so that maximum engineering data could be acquired for the purpose of supporting the launch of STS-1. In support of this basic objective, a number of criteria were established as pertinent to the selection process. Panel locations of special interest were: where loads due to aerodynamic shock waves and boundary-layer noise were large; where large stresses due to panel deflection occurred; and where residual surface roughness of the tiles posed a potential hazard to the Thermal Protection System.

With the establishment of the selection process, three TPS areas were selected for the CLOT program. They were:

1) acreage tile area aft of the forward ET attach point (bipod) - Configuration 20A.

2) tile area at the aft end of the nose gear doors, forward of the bipod - Configuration 20C.

3) tile area just forward of the inboard elevon on the Orbiter's lower wing surface - Configuration 20D (NOT TESTED).

Figure 1 shows the relative locations of the test panels on the Orbiter vehicle.

Model Description

Test Panels

The test panel (20A) made for OS53A was designed and fabricated to closely represent that portion of structure and TPS immediately aft of the Orbiter/External Tank bipod attach, which is subjected to shocks and aerodynamic turbulence created by the bipod. The general arrangement of Test Configuration 20A is shown in figure 2.

The construction of the test panel was such that the skin thickness, stringer configuration and spacing was maintained identical to the vehicle structure. Figure 3 depicts the general substrate design of panel 20A. Note that a full-scale bipod (with shortened legs) was attached to the test platform ahead of the 20A panel. The width of test panel 20A is 49.0 inches. This allowed a maximum number of stringers to be included while remaining within tunnel test platform width restraints.

Unique to the design of panel 20A were provisions for mounting to an in-tunnel hydraulic shaker.

Four spool pieces, one at each corner of the panel, were extended through the slots in the tunnel floor and bolted to a special frame which was attached to the shaker. Without this positive drive system, panel 20A was too stiff to be responsive to frequencies below 100Hz. The locations of these shaker mounts on the panel are shown in Figures 3 and 4.

The Thermal Protection System simulated on the 20A panel consisted of 9-PCF (pounds per cubic foot) densified silica tile on 0.160 in. SIP (strain isolation pad) and 9-PCF polyurethane foam tiles also on 0.160 in. SIP. The radius of curvature of the selected vehicle panels is quite large, making curvature effects minimal. Therefore, no attempt was made to simulate the curvature on the TPS or metal structure. The TPS installation for this panel is shown in figure 5. Each individual tile (silica and foam) is identified by the location numbers shown on figure 6.

The nose gear door panel 20C is a representation of the aft 41 inches of the Orbiter nose gear door structure, bipod area and TPS. The general arrangement of Test Configuration 20C is shown in figure 8.

As mentioned earlier, the tiles on these test panels were fabricated and installed flat, as a compromise to simulate the large radius of curvature on the vehicle. In addition, since the actual nose gear door structure is extremely rigid, the internal structure of test panel 20C utilized the same sandwich construction to simulate the actual stiffness of the doors, and was then surrounded by actual skin/stringer construction.

The general substrate design of 20C is shown in figure 9 and the TPS pattern is depicted in figure 10. Details of the nose gear door thermal barriers can be found in figure 11. Foam tile and real silica tile are identified by those numbers shown in figure 12.

The 20C test panel consists of direct-bond foam fairings around real tiles; i.e., the real tiles are mounted on SIP and the foam fairings are glued directly to the metal without SIP.

The 1/2-scale bipod was physically attached to a guide rail on the test platform just aft of test panel 20C (as shown in figure 13). During test runs the bipod was translated aft to maintain correct shock locations on the panel. The bipod was built in such a way as to simulate the correct mold line of the bipod attach bolt head and close-out structure around the foam fairings.

Model Description (Continued)

Calibration Panels

Two heavily instrumented calibration panels were built as high fidelity representations of their corresponding test panels (one for 20A and one for 20C). Only the 20A Calibration panel was tested during CLOT. It was installed in the same test platform as the 20A test panel (under the same test conditions) to fully calibrate and map the test conditions in the tunnel for the test panel runs. The 20C Calibration panel was built but never tested during OS53B.

Structurally, the 20A Calibration panel was identical to the 20A test panel. That is, the structural assembly drawings for the 20A test panel also define the structure for the 20A Calibration panel.

The Thermal Protection System (TPS) on the 20A Calibration panel consists of polyurethane foam tiles (9-PCF) bonded on SIP to exactly match the pattern of real tiles on the test panel. Not only does this duplicate airflow through tile gaps/SIP, etc., but also maintains a close degree of flexibility and dynamic response between the test panel and the calibration panel. TPS arrangement and tile identification numbers for the 20A Calibration panel are given in figure 7.

Model Description (Continued)

Test Platform and Bipod

The panels were mounted on a support structure (test platform) attached to the floor of the wind tunnel. The aerodynamic surfaces of this test platform were two-dimensional and extended from one sidewall of the tunnel to the other. The test platform was designed to be shimmed-up off the tunnel floor so that the boundary layer upstream of the test platform would flow underneath the platform through a gap between the lower surface of the test platform and the slotted floor of the wind tunnel. It became necessary, however, to close off this gap in order to achieve the proper tunnel environment for both the 20A and 20C configurations.

The design frontal area of the platform was kept to a minimum to reduce tunnel blockage and still accommodate the depth of the panels tested. All of the panels were mounted in the upper portion of the platform so that the simulated vehicle outer mold line (OML) would be flush with the upper surface of the test platform. Panel locations relative to the test platform are shown in figure 14.

Actual full-size bipod flight hardware was supplied by NASA/MSFC and was adapted for this test. The bipod was modified by truncating the legs to reduce the amount of tunnel blockage for the 20A configuration. A 1/2-scale bipod model was also provided by LaRC for use with configuration 20C. This bipod was mounted to a guide rail and could be translated axially by a hydraulic actuator. Its legs were also truncated to obtain minimum blockage. The bipod positions relative to the test panels and the test platform can be seen in figures 15 and 16.

INSTRUMENTATION

Both test panels and the 20A calibration panel were instrumented with static and dynamic pressures, accelerometers, strain gages, and other special instrumentation necessary to determine SIP/Structure interface loads and tile motions. The 20A calibration panel was highly instrumented with static pressure taps and Kulite microphones to determine the pressure field/environment over the area of tiles for the 20A test panel. A reference group of static and dynamic pressures was located in the test platform alongside the test panels and calibration panel to assist in correlating the calibration panel runs to the test panel runs.

The test panels had one or more selected tiles which were instrumented in order to determine loads and resulting motions. This instrumentation consisted of six accelerometers potted in one or two tiles on each test panel. These same tiles were instrumented for static pressures under the SIP and in the gap areas in order to determine the forcing functions. In addition, microphones were located in the gaps and SIP areas to measure the high-frequency forcing function caused by the fluctuating boundary layer. Accelerometers were located on the tile substructure in these areas along with a general coverage in other areas of the test panel. Special NASA/ARC "Coe" instrumentation (a strain gaged diaphragm for measuring SIP to structure stresses) was also utilized on one tile on test panels 20A and 20C. Deflectometers were installed in panel 20A to determine tile deflections.

An instrumentation summary for test configuration 20A is presented in Table I. This table includes information for both the calibration panel and the test panel. A similar summary for test configuration 20C can be found in Table II.

The signal from all Kulites on all panels was split into AC and DC components. This provided a static and dynamic pressure value for each Kulte measurement.

General design of Kulite installation inside foam or real tiles is presented as figure 34. Figure 35 shows typical Kulite installation in gaps between filler bar and SIP. Typical installation of accelerometers in SIP-mounted tile is shown in figure 36. OML surface static pressures and Kulites which are installed in direct-bond foam areas are depicted in figure 37.

LaRC provided a dummy or "precal" panel to be utilized for tunnel checkout. LaRC and NASA/ARC jointly provided instrumentation for this panel. Static pressure instrumentation (supplied by LaRC) is discussed more fully in Volume II of the "CLOT Test Data Reduction Plan," by H. F. Thornton (See references). Also described in this reference is the ARC "COE" tile assembly which was installed in the precal panel at the same location as tile #39 on the 20A calibration and test panels. Net loads measured from the precal panel COE tile (which was mounted on a "rigid" substrate) compared with similar information measured on the COE tile #39, which was bonded to "flexible" skin/stringer substrate on test panel 20A.

Test Configuration 20A Instrumentation

Figures 17 and 18 show an overall view of the instrumentation on calibration panel 20A. One real silica tile (#39/-036) was bonded on this foam tile calibration panel and was heavily instrumented with Kulites, as shown in figure 19. Also shown in this figure is foam tile #50, which contained Kulite instrumentation. A complete list of calibration panel instrumentation is contained in Table III which gives measurement numbers, locations, and types.

Test panel 20A overall instrumentation is depicted in figures 20 and 21 and tabulated in Table IV. There are two of the 40 total real tiles on this panel which were especially heavily instrumented: tile 39 (-006) and tile 50 (-005); Tile 39 is a 6x6-in. tile which contains Kulites, accelerometers, deflectometers, pressure taps, and the ARC (COE) balance; as depicted in figures 22 and 23. Instrumentation details of tile 50 (a 3x6-in tile) are shown in figure 25. As mentioned earlier, special instrumentation was employed on tile 39. Depicted in figure 23 is the special NASA/ARC-supplied "COE" balance which measures SIP-to-structures stresses. Four "Bently" deflectometers were also utilized underneath this tile; these are shown in figure 24, and were used to measure tile deflections. This panel also contained two 6x6 silica tiles (Nos. 51 and 52) which were accelerometer "monitor" tiles. The orientation of these accelerometers is depicted in figure 26. Each monitor tile contained two accelerometers and one Kulite sensor.

Test Configuration 20C Instrumentation

Test panel 20C overall instrumentation is depicted in figures 28 thru 33 and tabulated in Table V. Two of the 21 silica tile on the 20C test panel were heavily instrumented with accelerometers. Tile 34 (-009) is a 9-PCF silica tile with accelerometers oriented as shown in figure 29. Tile 21 (-008) is shown in figure 30. This tile is a 22-PCF silica tile and contains accelerometers and the ARC "COE" tile balance (see figure 31).

Test Platform Instrumentation

LaRC was responsible for installing static pressure taps in the test platform, around the test articles. These pressure taps were used as a check on test condition consistency between test panel and calibration panel runs.

Test platform instrumentation is depicted in figure 38 and tabulated in Table VI. As can be seen from the figure, a single row of static pressure taps was placed on the upper and lower surface of the test platform 35 inches to the right of the tunnel $\mathbb{C}_L$ (looking upstream). No matter which test configuration panel was installed, these taps (which extended from the leading to the trailing edge of the platform) were monitored to assure similarity of test conditions between runs of the "precal", calibration, and test panels.

DFI - Development Flight Instrumentation

Each of the test panels for 20A and C contained tiles which were instrumented with DFI on OV102. These tiles were in the same location relative to the test panels as they are on OV102.

Wherever possible, this instrumentation was monitored during the test. However, the main purpose in including DFI on CLOT was to subject these tiles to ascent loads, and observe the behavior of tiles with reduced SIP "footprint" areas and increased tile weight due to instrumentation.

Figure 27 shows the DFI tiles (26, 27 and 48) on the 20A test panel.

DFI tiles on the 20C test panel (19 and 20) are depicted in figure 32.

TEST OPERATIONS

Subscale Test

Prior to the OS53 test, Langley Research Center conducted subscale tests of the bipod and test platform in their 1 1/2-ft transonic DFA (Diffuser Flow Apparatus). Test variables were:

1. Mach number (from 0.7 to 1.2)
2. Gap height between the tunnel floor and the test platform (0.2 to 0.6 inches)
3. Bipod-off and bipod lengths (5.29 to 9.20 inches)
4. Bipod forward (20A) and bipod aft (20C)
5. Slot suction
6. Re-entry flap position

Despite the large amount of tunnel blockage caused by the presence of the bipod, the following results were achieved:

1. The nozzle Mach number at the leading edge of the platform was lower in the DFA than in the eight-foot TPT.
2. Suction arrangement and slot geometry changes were effective and necessary.
3. Desired flow was achieved for the forward bipod location (20A) with a full-scale bipod.
4. Desired flow was not achieved for the aft bipod location (20C) until tunnel choke plates and a 1/2-scale translatable bipod were installed in the tunnel.

Calibrations

LaRC performed calibration tests in the 8-foot TPT after successful subscale testing was completed in the DFA. These calibration runs consisted of test runs on a full-size dummy (precal) panel (supplied by LaRC) mounted in the test platform. Both the forward and aft-mounted bipod positions (20A and 20C) were tested (see figures 15 and 16 respectively). Calibration and checkout of all tunnel modifications were performed at this time. These included but were not limited to:

1. "Clear tunnel" runs with the test platform and precal panel installed
2. Operation and translation of the half-scale bipod for 20C, and tunnel operation with a fixed full-scale bipod for 20A
3. Deployment of the diffuser spoilers using the automatic drum and follower
4. Operation of the test section suction box system
5. Checkout of the shaker system for 20A

The items listed above were checked out with the tunnel in three modes: at ambient conditions, various steady state flow conditions, and during dynamic profile runs.

Rockwell was responsible for the following, before shipment of the panels to LaRC:

1. Basic electrical checkout and response of all Kulites, accelerometers and strain gages
2. Complete leak and continuity check of all static pressure tubes on all panels
3. Calibration of ARC tile balances and deflectometers, and
4. Determination of all three direction cosines for the 45° skewed accelerometer in tile #39 (test panel 20A), and tile weight and C.G. location.

NASA/LaRC and Rockwell were jointly responsible for:

1. In-tunnel "end-to-end" calibrations of all Kulites (differential and absolute)
2. System continuity and response of all accelerometers, strain gages, tile balances, and deflectometers; and
3. A complete system leak check of all static pressure tubes between transducer and orifice.

LaRC was responsible for:

1. Complete calibration and checkout of the in-house electronically scanned pressure (ESP) sensor system
2. Checkout and calibration of all FM tape recording equipment and associated NEFF amplifiers
3. Checkout of both HP9845 minicomputers and all peripheral equipment.

Detailed calibration procedures for test article instrumentation and tunnel instrumentation are contained in reference 5.

Shaker Support System

LaRC provided a hydraulic shaker and fixture that were attached directly to test panel 20A. This mechanical vibration system provided motion in the Zo axis, and is depicted in figure 39.

The special aluminum fixture was rigidly attached between the hydraulic actuator and the test panel. Four individual support arms connected the test panel to the shaker fixture through the slots in the wind tunnel test section. Attachment details are shown in figures 3 and 4.

Four air bags, which suspended a 75K pound reaction mass, were used to isolate the shaker system from the tunnel structure. Fixture restraints or guides were provided at 2 places to eliminate test panel motion along the Xo or Yo axes.

Shaker operation during test runs conformed to the low-frequency spectrum for STS-1 and design trajectories as depicted in figure 40. Detailed operational procedures are contained in reference 5.

Inspections

Inspections before a test run or series of runs were performed in the following manner on panels with real tile:

1. A complete alcohol evaporation inspection of the coated surfaces of each Silica Reusable Surface Insulation (SRSI) tile coating (Type II MT0501-506) per MPP No. 501MT506M02 with an individual tile scale crack map record per MT0501-506
2. SRSI tile step measurements per specification No. MT0501-533 and SRSI Tile Gap Measurements per MT0501-527, and
3. Detailed photographs showing test article tile condition before test, including any cracks or damage

Within one hour after completion of each test run, these inspections were made:

1. Detailed photographs of the same areas at the same position as prior to test
2. Step and gap measurements, same as prior to test, and
3. Alcohol evaporation inspection same as prior to test.

The following general TPS inspection criteria were used to determine if a tile was acceptable or unacceptable for continued testing:

1. Loss of tile(s) during test runs indicates immediate test abort
2. Loss of a portion or piece of tile(s) which is beyond the scope of a standard TPS repair also is grounds for test abort
3. Lifting of tile(s) by an amount equal to or greater than the SIP thickness indicates tile failure and test abort.

Installation

After checkout of the new tunnel modifications, calibration data from the dummy panel tests were analyzed and compared with the desired flight simulation and trajectory data. After several modifications to the tunnel and to the test platform geometry, a satisfactory simulation was achieved and approved by NASA and Rockwell. Then, the dummy panel was removed from the test platform.

Calibration panel 20A was inspected and prepared outside of the tunnel, by first attaching the four shaker mounts and carrying handles. With all tunnel hardware already installed in the test section, the calibration panel was then installed in the test platform and all instrumentation hooked up. Finally, the full-scale bipod was fastened to the test platform, just ahead of the calibration panel. See figure 15 for installation details.

When test runs were completed on the 20A calibration panel, TPS inspections were performed and data from the panel were analyzed. The hydraulic shaker was also operated during these runs and adjusted to obtain the correct simulation of the Flight Frequency spectrum.

Test panel 20A was prepared in the same manner as described for the calibration panel. After removal of the calibration panel, test panel 20A was installed as depicted in figure 15.

At the conclusion of testing for the 20A configuration, the following steps were taken to prepare for the 20C configuration.

1. Inspected and removed the 20A test panel and shaker fixtures
2. Removed the full-scale bipod
3. Completed preliminary tests in the DFA to develop proper flight simulation for the 20C configuration
4. Installed the precal panel and required choke plates, corner fillets, vortex generators, and aft bipod (half-scale)
5. Ran tests in the 8-foot TPT and made modifications to achieve a proper flight simulation
6. Removed precal panel and 1/2-scale bipod
7. Installed the new center section in the test platform to accommodate the 20C panels
8. Before the 1/2-scale bipod was attached to the guide rail on the test platform, all TPS inspections and checkout of panel instrumentation were performed.

The panel was then installed in the test platform and instrumentation hooked up; after this, the bipod was attached to the rail (see figures 13 and 16).

When tests on the 20C test panel were complete, the panel was removed from the test platform. The 20C calibration panel was moved to the test section but never installed and hooked up, per an agreement among RI, LaRC, and JSC.

Test Conditions

The tunnel was operated so that the dynamic pressure, and hence, the shock-wave strength variations were similar to those which occur on the corresponding orbiter panels during the high-load (transonic) portion of the launch trajectory. Freestream conditions for this trajectory are shown in figure 41.

The flight boundary-layer thickness was roughly approximated so that test boundary-layer noise and the noise due to shock-wave/boundary-layer interaction would be similar to those experienced in flight. The local dynamic pressure history, shock strength history, and shock location history during the peak ascent load period were also duplicated as closely as possible.

Table VII and figure 42 thru 54 describe those conditions which CLOT testing attempted to duplicate in the tunnel for the 20A configuration. For the 20C test configuration (aft bipod) local conditions are described in figures 55 thru 59. The Discussion of Test Results section discusses how well CLOT matched the desired test conditions.

Test Procedure

Tests on the 20A configuration were conducted in three phases. First, all tunnel modifications were made and all operational problems resolved. During this procedure, sufficient instrumentation was utilized to check out the tunnel. Next, a high-fidelity model of the test panel was tested.

This calibration panel, which was heavily instrumented, was used to define the test panel environment in great detail. Finally, the test panel itself was tested. Although this panel was instrumented, the instrumentation density in the test region was less than that on the high-fidelity calibration panel because the realism of the tiles could not be compromised. For the 20C configuration, the above test procedure was changed because of time constraints. The dummy panel (wooden precal panel) was used in place of the actual calibration panel by adding more instrumentation on it to define tunnel environment. After this phase, the test panel was installed and tested to obtain data for removal of the restraint to the STS-1 launch. The 20C calibration panel was never tested.

The time-variant test conditions for the high-fidelity calibration panel and the test panel matched as closely as possible. The dynamic pressure was varied by deflecting the wind tunnel diffuser spoilers, which are located downstream of the test section at the entrance to the diffuser. With the tunnel drive at full power and the total pressure at approximately 3/4 atmosphere, the total pressure and Mach number were varied from 400 PSF and 0.7 to 650 PSF and 1.3 as the diffuser flaps moved from fully closed to fully open. Therefore, the total pressure history of the ascent trajectory from about 25 seconds after liftoff to 70 seconds after liftoff was closely approximated by setting the total pressure and drive power to the values indicated above, and varying the diffuser flaps from fully closed to fully open and back to fully closed. It should be noted that during the test, local aerodynamic conditions at the panel rather than free-stream conditions were simulated.

Although the flight dynamic pressure history was simulated, the flight Mach number history was not because the flight Mach number continues to increase as the dynamic pressure decreases, but the wind tunnel Mach number drops. Therefore, some articulation of tunnel closure shock was required in order to position shock waves properly during the dynamic pressure reduction portion of the test for test configuration 20A. Shock locations and strengths for the 20A panel location on the orbiter are shown in figure 42. Local conditions on the 20C panel are shown in figure 55.

For the 20C configuration (located ahead of the bipod), the panel was located in the test section, where the tunnel upper and lower walls are slotted, and the bipod was attached to the guide rail as discussed earlier. In order to test panel 20A (behind the bipod), the bipod was located at the effective tunnel throat, where the slots start, and the panel was located downstream of the throat in the test section. This arrangement permits supersonic flow behind it.

LaRC produced a detailed "Tunnel Test and Operational Procedures..." document for each panel tested in the 8-foot TPT. These documents also served as a Quality Control sign-off list during the CLOT tests. They are listed as reference 5 in this report.

A run schedule for both the 20A and the 20C configurations is presented as Tables VIII, IX and X of this report.

Data Reduction

Model static pressure data and tunnel test conditions were reduced on-line during each run using an in-house HP9845 mini-computer with plotting capability. A second HP9845 was used to store and plot Kulite RMS pressure data sampled and read by a NEFF620.

All model static pressures were reduced to absolute pressure in psia. All dynamic data including fluctuating pressure measurements, accelerometer and strain gage signals, were recorded on six 28-channel FM tape recorders, processed (reduced to engineering units) and analyzed on-site by the data review team, which consisted of NASA/LaRC, JSC, ARC and Rockwell personnel.

All three data acquisition systems had a common IRIG-A time-code for correlation of test data. For select instrumentation requiring a high degree of correlation, a special effort was made to record the information on the same recorder.

Mini-computer data were reduced and stored on tape cassettes. The tapes were then reformatted onto a 9-track tape compatible with LaRC's data reduction center (ACD), and are available to be plotted in other formats as desired. FM magnetic tape data are at ACD for temporary maintenance in a special storage area, and can be digitized upon request. All photographic data are maintained by tunnel personnel at LaRC and are also available upon request.

The entire CLOT test data reduction plan was documented by LaRC personnel in five volumes as listed in reference 8. Due to the test complexity and enormous volume of information obtained during the CLOT program, this report does not contain any tabulated or plotted data.

REFERENCES

1. Burrows, R.R., "Pretest Information for Combined Loads Orbiter Test (CLOT) OS53A, B and C in the LaRC 8' TPT Using TPS Flow Test Articles 20A, 20C and 20D," Rockwell report #SOD80-0359, dated Sept. 1980. (Supplement I dated Nov., 1980; Supplement II dated Feb., 1981).

2. Cade, D.H., Lindekugel, G.R., Zodorozny, E.A., "TPS Flow Test Program Final Report," Rockwell report #STS81-0398, dated May 15, 1981.

3. Pearson, P.R., "Quick Look Test Results on CLOT Panel 20A," Rockwell letter #SAS/AERO/81-118, dated February 18, 1981.

4. Pearson, P.R., "Test Results on CLOT Test Panel TC-20C," Rockwell letter #SAS/AERO/81-448, dated June 23, 1981.

5. Kiser, C.C., "Combined Loads Orbiter Test (CLOT) OS53A and B Tunnel Test and Operational Procedures for 8' TPT Tests numbered (904 thru 909) using (PRECAL, TC-20A CAL, TC-20A TEST, TC-20C TEST) Panel," NASA/Langley Research Center Report for CLOT program (written in five separate reports, one for each panel).

6. Schuetz, P.H., "Test Environments and Results of CLOT Panel 20A," Rockwell Internal Letter #V&A-380-301-81-30, dated 3-6-81.

7. Schuetz, P.H., "Unsteady Environment and Responses of the Shuttle Combined Loads Orbiter Test (CLOT)," Rockwell Report #STS81-0697.

8. Thornton, H.P., Jr., "CLOT Test Data Reduction Plan (Volumes 1-5)," NASA/Langley Research Center Report for CLOT program; First draft dated Nov.6, 1980.

9. Victer, I.F., "TPS Combined Loads Test: Memorandum of Understanding," Rockwell letter #391-101-80-014, dated April 9, 1980.

10. Bobbitt, P.J., Edwards, C.L.W., and Barnwell, R.W., AIAA paper, No.82-0566, "The Simulation of Time Varying Ascent Loads on Arrays of Shuttle Tiles in a Large Transonic Tunnel."

TABLE I

INSTRUMENTATION SUMMARY

PANEL 20-A

		STATIC PRESSURE				KULITE									STRAIN		ACL	DISA	
		EDGE SURFACE	FILLER BAR	SIP	S/F GAP *	EDGE SURFACE	TILE SURFACE	TILE INSIDE	SIP	FILLER BAR	MID-SIDE GAP	S/F GAP	STR. BOTTOM	STR TOP	STR	TILE	SKIN/TILE	COE LOAD CELL	TOTAL
CAL PANEL	GROUPS	28	18	5	0	② 24	① 70	① 6	② 1	0	① 5	① 3	15	0	26	0	0	0	201
	SUB TOTAL	51				109							15		26		0	0	
TEST PANEL	GROUPS	28	21	19	9	② 24	① 4	① 2	② 8	② 11	0	0	15	5	30	③ 18	4	12	210
	SUB TOTAL	77				49							20		48		4	12	

① 81 KULITES - XCW - 093 ABSOLUTE

② 28 KULITES - XCQH - 093 - 15D REF

③ ACC - ENDEVCO 2250

* S/F = SIP/FILLER BAR

TABLE II
INSTRUMENTATION SUMMARY

PANEL 20C

* 20 C CALIBRATION PANEL NOT TESTED

		STATIC PRESSURE				KULITE							STRAIN		ACL		DISA		
		EDGE SURFACE	FILLER BAR	SIP	S/F GAP*	EDGE SURFACE	TILE SURFACE	TILE INSIDE	SIP	FILLER BAR	MID-SIDE GAP	S/F GAP	STR. BOTTOM	STR TOP	STR	TILE	SKIN/TILE	COE LOAD CELL	TOTAL
*CAL PANEL	GROUPS	19	12	18	0	(2) 13	(1) 44	(1) 16	(1) 2	(1) 4	(1) 10	(1) 5	4	0	8	0	0	0	145
	SUB TOTAL	39				94							4		8		0	0	
TEST PANEL	GROUPS	19	12	25	7	(2) 13	(1) 11	(1) 0	(2) 8	(2) 8	(1) 0	(2) 0	4	0	8	(3) 14	0	8	137
	SUB TOTAL	63				40							4		22		0	8	

(1) 92 KULITE XCW – 093 ABSOLUTE

(2) 42 KULITE XCQH – 093 DIFFERENTIAL

(3) 14 ACCELS – ENDEVCO – 2250

* S/F = SIP / FILLER BAR

TABLE III

20A CALIBRATION PANEL INSTRUMENTATION

ESP NO.	ROCKWELL NO.	SENSOR TYPE	SENSOR LOCATION, in. X FROM FRONT EDGE OF PANEL	Y FROM PANEL ℄ (RT-)	Z FROM PANEL IML (OML-)	PANEL Z LOCATION	TILE NO. & TYPE
4-24	P24	STATIC PRESSURE	1.0	17.25	-1.90	OML SURFACE	EDGE FOAM BLOCKS
4-25	P25			9.75			
4-26	P26			1.25			
4-27	P27			-9.75			
4-28	P28			-17.25			
4-29	P41	STATIC PRESSURE	33.75	1.1	-0.05	F/B TILE GAP	50/49
4-30	P43		37.0	2.2			50/38
4-31	P46		39.2	4.25			50/38/39/51
4-32	P47		38.0	5.3			50/51
5-01	P48		36.9	6.4			50/51/62
5-02	P49		34.65	4.25			50/62
5-03	P51		41.2	2.2			39/38
5-04	P53		45.3	2.2			39/27
5-05	P55		47.5	4.25			39/27/40
5-06	P56		45.5	6.3			39/40/52
5-07	P58		43.35	8.5			39/51/52
5-08	P59		41.2	6.3			39/51
5-09	P72		41.2	-6.3			25/26
5-10	P73		39.0	-4.25			25/26/27/38
5-11	P77		47.6	-4.25			17/26/27
5-12	P78		45.5	-6.3			26/16/17
5-13	P79		45.5	-2.0			26/27

TABLE III (Continued)

ESP NO.	ROCKWELL NO.	SENSOR TYPE	SENSOR LOCATION, in. X FROM FRONT EDGE OF PANEL	Y FROM PANEL ℄ (RT-)	Z FROM PANEL IML (OML-)	PANEL Z LOCATION	TILE NO. & TYPE
4-01	P1	STATIC PRESSURE	1.0	-23.5	-1.90	OML SURFACE	EDGE FOAM BLOCKS
4-02	P2		7.0				
4-03	P3		16.0				
4-04	P4		24.0				
4-05	P5		32.0				
4-06	P6		40.0				
4-07	P7		48.0				
4-08	P8		56.0				
4-09	P9		64.3				
4-10	P10			-17.25			
4-11	P11			-9.75			
4-12	P12			1.25			
4-13	P13			9.75			
4-14	P14			17.25			
4-15	P15			23.5			
4-16	P16		56.0				
4-17	P17		48.0				
4-18	P18		40.0				
4-19	P19		32.0				
4-20	P20		24.0				
4-21	P21		16.0				
4-22	P22		7.0				
4-23	P23		1.0				

TABLE III (Continued)

ESP NO.	ROCKWELL NO.	SENSOR TYPE	SENSOR LOCATION, in. X FROM FRONT EDGE OF PANEL	Y FROM PANEL ℄ (RT-)	Z FROM PANEL IML (OML-)	PANEL Z LOCATION	TILE NO. & TYPE
5-14	P80	STATIC PRESSURE	41.2	-2.0	-0.05	F/B TILE GAP	26/38
5-15	P81		43.3	2.55		SIP	39
5-16	P82		41.65	4.25			39
5-17	P83		45.0	4.25			39
5-18	P84		43.3	6.0			39
5-19	P85		35.9	3.25			50

TABLE III (Continued)

CABLE NO.	ROCKWELL NO.	SENSOR TYPE	SENSOR LOCATION, in. X FROM FRONT EDGE OF PANEL	Y FROM PANEL ℄ (RT-)	Z FROM PANEL IML (OML-)	PANEL Z LOCATION	TILE NO. & TYPE	TAPE RECORDER NO.
K01	K1	KULITE	1.0	-23.25	-1.90	OML SURFACE	EDGE OF FOAM BLOCKS	C1
K02	K2	XCQH-093-15D	7.0					C2
K03	K3		16.0					C3
K04	K4		32.0					C4
K05	K5		40.0					C5
K06	K6		48.0					C6
K07	K7		64.3					C7
K08	K8			-17.0				C21
K09	K9			-9.5				D7
K10	K10			1.5				A1
K11	K11			10.5				D15
K12	K12			17.5				B23
K13	K13			23.25				C8
K14	K14		48.0					C9
K15	K15		40.0					C10
K16	K16		32.0					C11
K17	K17		16.0					C12
K18	K18		7.0					C13
K19	K19		1.0					C14
K20	K20			17.5				C22
K21	K21			10.5				D8
K22	K22			1.5				A2
K23	K23			-9.5				D1

TABLE III (Continued)

CABLE NO.	ROCK-WELL NO.	SENSOR TYPE	SENSOR LOCATION, in. X FROM FRONT EDGE OF PANEL	Y FROM PAN-EL ℄ (RT-)	Z FROM PANEL IML (OML-)	PANEL Z LOCATION	TILE NO. & TYPE	TAPE RECORDER NO.
K24	K24	KULITE (REF)	1.0	-17.0	- 1.90	OML SURFACE	EDGE OF FOAM BLOCK	C15
		XCQH-093-15D						
KA01	K25	KULITE (ABS)	3.9	-0.8			75	D26
KA02	K26	XCW-093	4.0	2.13			75	D27
KA03	K27		7.0	9.75			81	D9
KA04	K28		7.0	17.25			86	C23
KA05	K50		7.0	-17.25			56	C16
KA06	K51		24.0				34	C17
KA07	K52		32.0				23	C18
KA08	K53		40.0				15	A3
KA09	K54		48.0				8	C19
KA10	K55		56.0				4	C20
KA11	K56		7.0	-9.75			66	D2
KA12	K57		16.0				58	D3
KA13	K58		24.0				47	D4
KA14	K59		40.0				25	D5
KA15	K60		48.0				16	D6

TABLE III (Continued)

CABLE NO.	ROCKWELL NO.	SENSOR TYPE	SENSOR LOCATION, in. X FROM FRONT EDGE OF PANEL	Y FROM PANEL ℄ (RT-)	Z FROM PANEL IML (OML-)	PANEL Z LOCATION	TILE NO. & TYPE	TAPE RECORDER NO.
KA16	K61	KULITE	29.0	-4.24	-1.90	OML SURFACE	48	D16
KA17	K62	ABS XCW-093	30.92				36	D17
KA18	K63		32.84				36	D18
KA19	K64		34.98				37	D19
KA20	K65		36.48				37	D20
KA21	K66		38.48				37	D21
KA22	K67		39.48				26	B1
KA23	K68		41.36					B2
KA24	K69		43.24					A4
KA25	K70		45.12					B3
KA26	K71		47.00					B4
KA27	K72		48.00				17	D22
KA28	K73		50.00				17	D23
KA29	K74		52.00				18	D24
KA30	K75		54.00				18	D25
KA31	K76		16.0	1.25			68	A5
KA32	K77		24.0				60	B24
KA33	K78		29.0				49	B25
KA34	K79		38.48				38	A6
KA35	K80		48.0				27	F24
KA36	K81		54.75				19	F25

TABLE III (Continued)

CABLE NO.	ROCKWELL NO.	SENSOR TYPE	SENSOR LOCATION, in. X FROM FRONT EDGE OF PANEL	Y FROM PAN. EL ℄ (RT-)	Z FROM PANEL IML (OML-)	PANEL Z LOCATION	TILE NO. & TYPE	TAPE RECORDER NO.
KA37	K82	KULITE (ABS)	29.0	4.24	-1.90	OML SURFACE	61	F5
KA38	K83	XCW-093	30.92				62	A7
KA39	K84		32.84				62	F6
KA40	K85		34.98				50	F7
KA41	K86		36.48				50	A8
KA42	K87		38.48				50	B10
KA43	K88		48.00				40	F8
KA44	K89		50.00				40	F9
KA45	K90		52.00				28	F10
KA46	K91		54.75				28	A9
KA47	K92		16.0	9.75			77	D10
KA48	K93		24.0				70	D11
KA49	K94		32.0				62	D12
KA50	K95		40.0				51	A10
KA51	K96		48.0				52	D13
KA52	K97		56.0				29	D14
KA53	K98		24.0	17.25			79	C24
KA54	K99		32.0				72	C25
KA55	K100		40.0				64	A11
KA56	K101		48.0				53	C26
KA57	K102		56.0				42	C27

TABLE III (Continued)

CABLE NO.	ROCK-WELL NO.	SENSOR TYPE	SENSOR LOCATION, in. X FROM FRONT EDGE OF PANEL	Y FROM PANEL ¢ (RT-)	Z FROM PANEL IML (OML-)	PANEL Z LOCATION	TILE NO. & TYPE	TAPE RECORDER NO.
KA58	K103	KULITE (ABS)	41.4	-6.1	-1.90	OML SURFACE	26	B5
KA59	K104	XCW-093	45.3	-6.1				B6
KA60	K105		41.4	-2.2				B7
KA61	K106		45.3	-2.2				B8
KA62	K107		43.4	-1.1				B9
KA63	K108		36.6	2.3			50	F11
KA64	K109		36.75	2.1	-0.95	GAP H/2	38/50	B21
KA65	K110		34.45	4.1	-0.95	GAP H/2	62/50	B22
KA66	K111		40.95	1.8	-1.90	OML SURF.	38	B11
KA67	K112		41.05	2.1	-0.95	GAP H/2	38/39	B15
K25	K113	XCQH-093-15D	43.65	1.1	-0.05	S/F GAP	39	B18
KA69	K114	XCW-093 (ABS)	43.75	1.25	-1.6	TILE SUB-SURF	39	F12
KA70	K115		44.8	2.1	-0.95	GAP H/2	27/39	B16
KA71	K116		45.65	2.1	-1.90	OML SURF.	27	B12
KA72	K117		46.7	4.2	-1.6	TILE SUB-SURF.	39	F13
K26	K118	XCQH-093-15D	46.75	4.3	-0.05	S/F GAP	39	B19
KA74	K119	XCW-093 (ABS)	47.05	4.3	-1.90	OML SURF.	39	A12
KA75	K120		45.1	6.2	-1.90	OML SURF.	39	B13
KA76	K121		43.45	4.3	-0.40	TILE SUB-SURF	39	F14
K27	K122	XCQH-093-15D	43.15	4.0	-0.05	SIP	39	A13
KA78	K123	XCW-093	43.15	4.25	-1.90	OML SURF.	39	A14
KA79	K124	(ABS)	42.9	4.25	[illegible]	[illegible]		[illegible]

TABLE III (Continued)

CABLE NO.	ROCK-WELL NO.	SENSOR TYPE	SENSOR LOCATION, in. X FROM FRONT EDGE OF PANEL	Y FROM PANEL ℄ (RT-)	Z FROM PANEL IML (OML-)	PANEL Z LOCATION	TILE NO. & TYPE	TAPE RECORDER NO.
K28	K125	XCQH-093-15D	39.55	4.3	-0.05	S/F GAP	39	B20
KA81	K126	XCW-093	39.65	4.2	-1.6	TILE SUBSURF.		F16
KA82	K127	(ABS)	39.4	4.3	-1.90	OML SURF.		A15
KA83	K128		39.5	4.1	-1.84	TILE SUB-SURF.		F17
KA84	K129		40.65	6.1	-1.03	GAP H/2	51/39	B17
KA85	K130		40.65	6.35	-1.90	OML SURF	51	B14
K29	K131	XCS -093-15G	7.0	4.5	1.6	SIDE OF HAT, POINTED DOWN	76	F18
K30	K135		40.0	8.5			51	A16

CABLE NO.	ROCKWELL NO.	SENSOR TYPE	SENSOR LOCATION, in. X FROM FRONT EDGE OF PANEL	Y FROM PAN. CL ℄ (RT-)	Z FROM PANEL IML (IML-)	PANEL Z LOCATION	TILE NO. & TYPE	TAPE RECORDER NO.
A01	A1	ENDEVCO 2222B	7.0	-19.4	1.67	HAT-UPPER	44	E1
A02	A2	ACCELEROMETER	18.25		1.7		33	E2
A03	A3		36.75				14	E3
A04	A4		55.75				4	E4
A05	A5		18.25	-7.76		HAT-UPPER CENTER	58	E5
A06	A6		36.75				25	E6
A07	A7		55.75				10	E7
A08	A8		7.0	0.75	0.2	T-FRAME FLANGE	75	E8
A09	A9		18.25				69/60	E9
A10	A10		36.75				38	E10
A11	A11		46.80				27	A17
A12	A12		55.75				19	E11
A13	A13		18.25	7.76	1.7	HAT-LOWER CENTER	77	E12
A14	A14		36.75	7.76	1.7		51	E13
A15	A15		7.0	19.4	1.67		87	E14
A16	A16		36.75	19.4	1.7		73	E15
A39	A39	ENDEVCO 2222B	17.6	0.5	4.2	FWD FRAME CAP	69/60	E16
A40	A40		55.1	0.5	4.3	AFT FRAME CAP	19	A18
A41	A41		3.5	-10.7	4.7	I-BEAM LIP		A19
A42	A42		3.4	-10.6	4.7			A20
A43	A43		3.4	-10.7	4.5			A21

TABLE III (Continued)

CABLE NO.	ROCKWELL NO.	SENSOR TYPE	SENSOR LOCATION, in. X FROM FRONT EDGE OF PANEL	Y FROM PANEL ℄ (RT-)	Z FROM PANEL IML (OML-)	PANEL Z LOCATION	TILE NO. & TYPE	TAPE RECORDER NO.
A44	A44	ENDEVCO 2222B ACCELEROMETER	3.4	10.7	4.52	I-BEAM LIP		A22
A45	A45		61.8	10.7	4.67			E17
A46	A46		62.0	10.8	4.67			E18
A47	A47		62.0	10.7	4.52			A23
A48	A48		62.0	-10.7	4.52			A24

TABLE III (Concluded)

CABLE NO.	ROCKWELL NO.	SENSOR TYPE	SENSOR LOCATION, in. X FROM FRONT EDGE OF PANEL	Y FROM PANEL ℄ (RT-)	Z FROM PANEL IML (OML-)	PANEL Z LOCATION	TILE NO. & TYPE	TAPE RECORDER NO.
S01	S1	STRAIN GAGE	20.50	-19.4	1.7	HAT SECTION	33 FWD FRAME	E19
S02	S2	350-Ω	37.85				14 MINI FRAME	E20
S03	S3		54.75				4 AFT FRAME	E21
S04	S4		20.50	-7.76			47 FWD	E22
S05	S5		37.85				25 MINI	E23
S06	S6		54.75				10 AFT	E24
S07	S7		20.50	0.0	1.6	I-CAP	60 FWD	A25
S08	S8		37.85				38 MINI	A26
S09	S9		54.75			HAT SECTION	19 AFT	E25
S10	S10		20.50	7.76	1.7		70 FWD	E26
S11	S11		37.85				51 MINI	E27
S12	S12		54.75				29 AFT	F1
S13	S13		20.50	19.4			84 FWD	F2
S14	S14		37.85				73 MINI	F3
S15	S15		54.75				42 AFT	F4
T01	T1	THERMOCOUPLE CHROMEL ALUMEL	43.15	1.75	0.07	SKIN-BACKSIDE	39	

TABLE IV

20A TEST PANEL INSTRUMENTATION

ESP NO.	ROCKWELL NO.	SENSOR TYPE	SENSOR LOCATION, in. X FROM FRONT EDGE OF PANEL	Y FROM PANEL ℄ (RT-)	Z FROM PANEL IML (OML-)	PANEL Z LOCATION	TILE NO. & TYPE
401	P1	STATIC PRESSURE	1.0	-23.5	-1.90	OML SURFACE	EDGE FOAM BLOCKS
402	P2		7.0				
403	P3		16.0				
404	P4		24.0				
405	P5		32.0				
406	P6		40.0				
407	P7		48.0				
408	P8		56.0				
409	P9		64.3				
410	P10			-17.25			
411	P11			-9.75			
412	P12			1.25			
413	P13			9.75			
414	P14			17.25			
415	P15			23.5			
416	P16		56.0				
417	P17		48.0				
418	P18		40.0				
419	P19		32.0				
420	P20		24.0				
421	P21		16.0				
422	P22		7.0				
423	P23		1.0				

TABLE IV (Continued)

ESP NO.	ROCKWELL NO.	SENSOR TYPE	SENSOR LOCATION, in. X FROM FRONT EDGE OF PANEL	Y FROM PANEL ℄ (RT-)	Z FROM PANEL IML (OML-)	PANEL Z LOCATION	TILE NO. & TYPE
424	P24	STATIC PRESSURE	1.0	17.25	-1.90	OML SURFACE	EDGE FOAM BLOCKS
425	P25			9.75			
426	P26			1.25			
427	P27			-9.75			
428	P28			-17.25			
429	P29		16.8	-2.0	-0.05	SIP	59
430	P30		16.8	-1.2		S/F GAP	59
431	P31		15.6	-2.0		F-BAR TILE GAP	58/59/68
432	P32		39.0	-2.6		SIP	38
501	P33		40.7	-1.7		S/F GAP	
502	P34		37.0	0.8		SIP	
503	P35		39.0	0.8			
504	P36		41.0	0.8			
505	P37		36.7	1.5		S/F GAP	
506	P38		40.8	1.7			
507	P39		36.8	-1.5			
508	P40		33.8	2.1		SIP	50
509	P41		33.75	1.1		F-BAR	50/49
510	P42		34.55	1.3		SIP	50
511	P43		37.0	1.5		F-BAR	50/38
512	P44		35.65	3.4		SIP	50
513	P45		37.75	4.15		SIP	50

TABLE IV (Continued)

ESP NO.	ROCKWELL NO.	SENSOR TYPE	SENSOR LOCATION, in. X FROM FRONT EDGE OF PANEL	Y FROM PANEL ℄ (RT-)	Z FROM PANEL IML (OML-)	PANEL Z LOCATION	TILE NO. & TYPE
514	P46	STATIC PRESSURE	39.2	4.15	-0.05	F/B TILE GAP	50/38/39/51
515	P47		38.0	5.0			50/51
516	P48		36.75	6.3			50/51/62
517	P49		34.65	4.2		F-BAR	50/62
518	P50		40.7	4.2		SIP	39
519	P51		41.25	1.9		F-BAR	39/38
520	P52		43.2	1.45		SIP	39
521	P53		45.5	2.3		F-BAR	39/27
522	P54		46.0	4.2		SIP	39
523	P55		47.5	4.2		F-BAR	39/27/40
524	P56		45.5	6.2		F-BAR	39/40?
525	P57		43.2	7.0		SIP	39
526	P58		43.2	8.45		F-BAR	39/51/52
527	P59		40.9	6.15		F-BAR	39/51
528	P60		43.2	4.0		SIP	39
529	P61		34.8	8.45		F-BAR	51/62/63
530	P62		41.2	10.5		F-BAR	51/52/64
531	P63		49.8	10.5		F-BAR	40/41/52
532	P64		39.0	-11.1		SIP	25
601	P65		34.8	- 8.4		F-BAR	24/25/36
602	P66		36.3			SIP	25
603	P67		39.0			SIP	25
604	P68		43.7			F-BAR	16/25/26

TABLE IV (Continued)

ESP #	ROCKWELL NO.	SENSOR TYPE	SENSOR LOCATION, in. X FROM FRONT EDGE OF PANEL	Y FROM PANEL ℄ (RT−)	Z FROM PANEL IML (OML−)	PANEL Z LOCATION	TILE NO. & TYPE
605	P69	STATIC PRESSURE	36.75	−7.0	−0.05	S/F GAP	25
606	P70		39.0	−5.75		S/P	25
607	P71		40.9	−6.7		S/F GAP	25
608	P72		41.2	−6.3		F-BAR	25/26
609	P73		39.0	−4.2		F-BAR	25/26/27/39
610	P74		35.1	−3.9		S/F GAP	37
611	P75		35.9	−3.1		S/P	37
612	P76		36.5	−2.5		S/F GAP	37
613	P77		47.6	−4.2		F-BAR	17/26/27

TABLE IV (Continued)

CABLE NO.	ROCKWELL NO.	SENSOR TYPE	SENSOR LOCATION, in. X FROM FRONT EDGE OF PANEL	Y FROM PANEL ℄ (RT-)	Z FROM PANEL IML (IML-)	PANEL Z LOCATION	TILE NO. & TYPE
A01	A1	ENDEVCO 2222B	7.0	-19.4	1.67	HAT-UPPER	44
A02	A2	ACCELEROMETER	18.25		1.7		33
A03	A3		36.75				14
A04	A4		55.75				4
A05	A5		18.25	-7.76		HAT-UPPER CENTER	58
A06	A6		36.75				25
A07	A7		55.75				10
A08	A8		7.0	0.75	0.2	T-FRAME-FLANGE	75
A09	A9		18.25				69/60
A10	A10		36.75				38
A11	A11		46.80				27
A12	A12		55.75				19
A13	A13		18.25	7.76	1.7	HAT-LOWER CENTER	77
A14	A14		36.75	7.76	1.7		51
A15	A15		7.0	19.4	1.67		87
A16	A16		36.75	19.4	1.7		73
A17	A17	ENDEVCO 2250A	34.55	1.3	-1.15	TILE SUBSURFACE	50
A18	A18	ACCELEROMETER	35.0	1.1	-1.05		
A19	A19		37.7	3.6	-1.05		
A20	A20		37.5	4.2	-1.15		
A21	A21		36.75	3.8	-1.1		
A22	A22		35.4	3.3	-1.15		

TABLE IV (Continued)

CABLE NO.	ROCKWELL NO.	SENSOR TYPE	SENSOR LOCATION, in. X FROM FRONT EDGE OF PANEL	Y FROM PANEL ℄ (RT-)	Z FROM PANEL IML (OML-)	PANEL Z LOCATION	TILE NO. & TYPE
A23	A23	ENDEVCO 2250A	34.85	2.8	-1.05	TILE SUBSURFACE	50
A24	A24	ACCELEROMETER	39.75	4.4	-1.05		39
A25	A25		42.0	3.0	-1.15		
A26	A26		46.1	4.2	-1.15		
A27	A27		45.0	6.0	-1.05		
A28	A28		43.2	7.0	-1.15		
A29	A29		42.7	7.3	-1.05		
A30	A30		43.9	3.1	-1.1		
A31	A31		38.5	8.2	-1.05		51
A32	A32		39.0	8.4	-1.15		51
A33	A33		45.0	10.3	-1.05		52
A34	A34		45.5	10.5	-1.15		52
A35	A35	ENDEVCO 2222B	39.3	4.25	1.67	HAT SECTION	39
A36	A36	ACCELEROMETER	43.1	0.75	0.2	T-BEAM FLANGE	
A37	A37		47.0	4.25	1.67	HAT SECTION	
A38	A38		34.1	8.1	1.67	HAT SECTION	
A39	A-39		17.6	0.5	4.2	FWD FRAME CAP	69/60
A40	A-40		55.1	0.5	4.2	AFT FRAME CAP	19
A41	A-41		3.5	-10.7	4.7	I-BEAM LIP	
A42	A-42		3.4	-10.6	4.7		
A43	A-43		3.4	-10.7	4.5		

TABLE IV (Continued)

CABLE NO.	ROCKWELL NO.	SENSOR TYPE	SENSOR LOCATION, in. X FROM FRONT EDGE OF PANEL	Y FROM PANEL ℄ (RT-)	Z FROM PANEL IML (IML-)	PANEL Z LOCATION	TILE NO. & TYPE
A44	A44	ENDEVCO 2222B ACCELEROMETER	3.4	10.7	4.52	I-BEAM LIP	
A45	A45		61.8	10.7	4.67		
A46	A46		62.0	10.8	4.67		
A47	A47		62.0	10.7	4.52		
A48	A48		62.0	-10.7	4.52		

TABLE IV (Continued)

CABLE NO.	ROCKWELL NO.	SENSOR TYPE	SENSOR LOCATION, in. X FROM FRONT EDGE OF PANEL	Y FROM PANEL ℄ (RT-)	Z FROM PANEL IML (OML-)	PANEL Z LOCATION	TILE NO. & TYPE
C01	C1	COE LOAD CELL	42.6	2.2	0.0	IML SURFACE	39
C02	C2		44.0	2.2			
C03	C3		41.1	3.6			
C04	C4		42.6	3.6			
C05	C5		44.0	3.6			
C06	C6		45.3	3.6			
~~C07~~	~~C7~~		~~41.1~~	~~5.1~~			
C08	C8		42.1	5.1			
C09	C9		44.2	5.1			
C10	C10		45.1	5.1			
C11	C11		42.6	6.5			
C12	C12		44.0	6.5			

TABLE IV (Continued)

CABLE NO.	ROCK-WELL NO.	SENSOR TYPE	SENSOR LOCATION, in. X FROM FRONT EDGE OF PANEL	Y FROM PANEL ℄ (RT-)	Z FROM PANEL IML (OML-)	PANEL Z LOCATION	TILE NO. & TYPE
D01°	D1	BENTLY PROXIMITY XDUCER (7200-2150)	42.1	1.7	-0.1	SIP/FB GAP	39
D02	D2		44.3	1.7			
D03	D3		41.4	6.2			
D04	D4		45.1	6.2			
T01	T1	C-A Thermocouple	42.0	5.95	0.07		
T02	T2						
T03	T3						
T04	T4						
T05	T5						

TABLE IV (Continued)

CABLE NO.	ROCKWELL NO.	SENSOR TYPE	SENSOR LOCATION, in. X FROM FRONT EDGE OF PANEL	Y FROM PAN. EL ℄ (RT-)	Z FROM PANEL IML (IML-)	PANEL Z LOCATION	TILE NO.	TYPE
S01	S1	STRAIN GAGE	20.50	-19.4	1.7	HAT SECTION	33	FWD FRAME
S02	S2	350Ω	37.85				14	MINI FRAME
S03	S3		54.75				4	AFT FRAME
S04	S4		20.50	-7.76			47	FWD
S05	S5		37.85				25	MINI
S06	S6		54.75				10	AFT
S07	S7		20.50	0.0	1.6	I-CAP	60	FWD
S08	S8		37.85				38	MINI
S09	S9		54.75				19	AFT
S10	S10		20.50	7.76	1.7	HAT SECTION	70	FWD
S11	S11		37.85				51	MINI
S12	S12		54.75				29	AFT
S13	S13		20.50	19.4			84	FWD
S14	S14		37.85				73	MINI
S15	S15		54.75				42	AFT
S16	S16		20.50	0.0	0	IML SURFACE	60	FWD
S17	S17		54.75				19	AFT
S18	S18		20.50	7.76			70	FWD
S19	S19		37.85				51	MINI
S20	S20		54.75				29	AFT

TABLE IV (Concluded)

ESP No.	Rockwell No.	Sensor Type	Sensor Location, in.: X From front edge of panel	Sensor Location, in.: Y From panel ℄ (RT−)	Sensor Location, in.: Z From panel IML (OML−)	Panel Z Location	Tile No. & Type
4-01	P1	STATIC PRESSURE	7.00	−29.50	−1.90	SURFACE	1
2	P2		16.00				3
3	P3		26.00				4
4	P4		33.50				5
5	P5		41.00				6
6	P6		54.62	−28.00			46
7	P7			−17.00			48
8	P8			−10.00			50
9	P9			10.00			54
10	P10			17.00			55
11	P11			29.50			56
12	P12		41.00				45
13	P13		26.00				43
14	P14		7.00				40
15	P15			10.00			26
16	P16			−0.50			8
17	P17			−10.00			8
18	P18		60.62	10.00			55
4-19	P19		60.62	17.00			56
3-17	P74	static	25.50	0	−1.90	surface	
1-12	PT2	Total Tube	14.00	8.00	−4.4	≈ 2½" above surface	
3-18	P75	static	27.0	0	−1.90	surface	
3-19	P76	"	28.2	0	−1.90	surface	

TABLE V

20C TEST PANEL INSTRUMENTATION

ESP No.	ROCKWELL NO.	SENSOR TYPE	SENSOR LOCATION, in. X FROM FRONT EDGE OF PANEL	Y FROM PAN. CL (RT-)	Z FROM PANEL IML (OML-)	PANEL Z LOCATION	TILE NO. & TYPE
4-20	P28	STATIC PRESSURE	35.33	4.60	-0.050	SIP	31
21	P29		46.19	0.00		FILLER BAR	24-51
22	P30		45.78	0.00		SIP	24
23	P31		46.19	3.25		FILLER BAR	32-51
24	P32		45.78	3.25		SIP	32
25	P33		46.18	-7.95		FILLER BAR	21
26	P34		43.36	-2.52		SIP/FILLER BAR GAP	24
27	P35			-2.15		SIP	24
28	P36			-0.44		SIP	24
29	P37			1.28		SIP	24
30	P38			1.78		FILLER BAR	24-32
31	P39			2.16		SIP	32
4-32	P40			4.16		SIP	32
5-01	P41			5.62		SIP	32
2	P42			5.96		SIP/FILLER BAR GAP	32
3	P43		40.69	-0.84		SIP/FILLER BAR GAP	24
4	P44		41.04	-0.84		SIP	24
5	P45		40.67	4.50		SIP/FILLER BAR GAP	32
6	P46		41.04	4.50		SIP	32
7	P47		39.48	3.90		SIP	31
8	P48		39.79	3.90		SIP/FILLER BAR GAP	31
9	P49		37.42	1.78		FILLER BAR	23-31
5-10	P50		37.42	2.16		SIP	31

TABLE V (Continued)

ESP NO.	ROCKWELL NO.	SENSOR TYPE	SENSOR LOCATION, in. X FROM FRONT EDGE OF PANEL	Y FROM PANEL ℄ (RT-)	Z FROM PANEL IML (OML-)	PANEL Z LOCATION	TILE NO. & TYPE
5-11	P51	STATIC PRESSURE	37.42	4.16	-0.050	SIP	31
12	P52			5.76		SIP	31
13	P53			6.18		SIP/FILLER BAR GAP	31
14	P54		35.05	4.60		SIP/FILLER BAR GAP	31
15	P55		47.37	-4.75		SIP	21
16	P56		45.65	-2.41		SIP	21
17	P57		43.41	-5.49		FILLER BAR	18-21
18	P58			-4.38		SIP	21
19	P59			-2.27		FILLER BAR	21-24
20	P60		41.12	-6.63		SIP	21
21	P61		40.26	-5.81		FILLER BAR	17-20-21
22	P62		41.12	-4.21		SIP	21
23	P63		40.45	6.57		SIP	34
24	P64		41.31	7.65		FILLER BAR	32-34-35
25	P65		4045	9.45		SIP	34
26	P66		37.4	6.57		FILLER BAR	31-34
27	P67			8.94		SIP	34
28	P68			11.29		FILLER BAR	34-37
29	P69		35.41	8.40		SIP	34
30	P70		34.55	10.25		FILLER BAR	33-34-36
5-31	P71		35.41	11.28		SIP	34
3-15	P72		21.25	0.0	-1.90	SURFACE	
3-16	P73		24.25	0.0	-1.90	"	

TABLE V (Continued)

CABLE NO.	ROCKWELL NO.	SENSOR TYPE	SENSOR LOCATION, in. X FROM FRONT EDGE OF PANEL	Y FROM PAN. EL ℄ (RT-)	Z FROM PANEL IML (IML-)	PANEL Z LOCATION	TILE NO. & TYPE	TAPE RECORDER NO. (AC[illegible])
KA-1	K1	XCW-093-15A	7.00	-29.25	-1.90	PANEL EDGE SURFACE	1	A-1
KA-2	K2		26.00	-			4	A-2
KA-3	K3		41.00				6	A-3
K-01	K4	XCS-093-15G	54.62	-27.25			46	A-4
KA-4	K5	XCW-093-15A		-17.25			48	A-5 (D-27)
KA-5	K6			-10.25			50	A-6 (D-21)
KA-6	K7			10.25			54	A-7
KA-7	K8			17.25			55	A-8
KA-8	K9		41.00	29.25			45	A-9
KA-9	K10		7.00	19.25			40	A-10
K-02	K11	XCS-093-15G		9.75			26	A-11
K-03	K12			-0.50			8	A-12
K-04	K13			-9.37			8	A-13
KA-10	K14	XCW-093-15A	12.75	-0.50		PANEL MID-SURFACE	9	A-14
KA-11	K15		26.00	-30.00			11	A-15 (D-23)
K-05	K16	XCS-093-15G		- 9.00			11	A-16 (D-24)
KA-12	K17	XCW-093-15A		- 0.50			11	A-17 (D-25)
KA-13	K18			20.00			29	A-18
KA-14	K22		41.00	-20.00			12	A-19 (D-26)
KA-15	K39		41.00	20.00			39	A-20

TABLE V (Continued)

CABLE NO.	ROCK-WELL NO.	SENSOR TYPE	SENSOR LOCATION, in. X FROM FRONT EDGE OF PANEL	Y FROM PAN. ℄ (RT-)	Z FROM PANEL IML (OML-)	PANEL Z LOCATION	TILE NO. & TYPE	TAPE RECORDER NO. (ACME)
KA-16	K40	XCW-093-15A	48.44	-0.50	-1.90	BI-POD	51	A-21 (B-24)
KA-17	K41		48.44	4.05				A-22 (C-16)
KA-18	K42		54.65	5.15				A-23 (C-25)
KA-19	K43		59.45	0.00				A-24
K-06	K80	XCS-093-15G	35.62	11.21	-0.05	SIP	34	C-17 (C-8)
K-07	K81		46.19	-8.21		FILLER BAR	21	D-13 (B-16)
K-08	K82		45.65	-2.70		SIP	21	D-14 (B-17)
K-09	K83		43.63	-6.66		FILLER BAR	21-18	D-15 (B-18)
K-10	K84		43.65	-4.40		SIP	21	B-25 (B-19)
K-11	K85		43.65	-2.22		FILLER BAR	21-24	D-17 (B-20)
K-12	K86		41.35	-5.00		SIP	21	D-18 (B-21)
K-13	K87		40.26	-6.25		FILLER BAR	21-17	D-19 (B-22)
K-14	K88		41.34	-4.23		SIP	21	D-20 (B-23)
K-15	K89		40.23	6.67		SIP	34	C-18 (C-9)
K-16	K90		41.31	7.38		FILLER BAR	34-32-35	C-19 (C-10
K-17	K91		37.64	6.46		FILLER BAR	34-31	C-20 (C-11
K-18	K92			7.84		SIP	34	C-21 (C-12
K-19	K93			11.17		FILLER BAR	34-37	C-22 (C-13
K-20	K94		35.64	8.3		SIP	34	C-23 (C-14
K-21	K95		34.55	9.97		FILLER BAR	33-34-36	C-24 (C-15
KA-20	K111	XCW-093-15A	16.1	0	5.1	BOTTOM ℄, DOOR (POINTING AFT)		E-7
KA-21	K112		40.0	0	5.1	"		E-8

CABLE NO.	ROCK-WELL NO.	SENSOR TYPE	SENSOR LOCATION, in. X FROM FRONT EDGE OF PANEL	Y FROM PANEL ℄ (RT-)	Z FROM PANEL IML (OML-)	PANEL Z LOCATION	TILE NO. & TYPE	TAPE RECORDER NO.
A01	A1	ACCEL 2250	41.5	-6.8	-1.05	IN TILE	21	B-9
A-02	A2		40.7	-5.6	-1.00			B-10
A-03	A3		42.0	-4.5	-1.05			B-11
A-04	A4		45.0	-5.0	-1.00			B-12
A-05	A5		45.7	-4.3	-1.00			B-13
A-06	A6		45.7	-3.5	-1.10			B-14
A-07	A7		45.7	-2.1	-1.10			B-15
A-08	A8		35.0	9.9	-1.00		34	C-1
A-09	A9		35.0	11.3	-1.05			C-2
A-10	A10		36.5	9.8	-1.10			C-3
A-11	A11		39.9	6.2	-1.00			C-4
A-12	A12		39.9	7.8	-1.00			C-5
A-13	A13		39.9	8.9	-1.05			C-6
A-14	A14		38.95	9.6	-1.00			C-7
A-15	A15	ACCEL 2215 OR 2222	7.66	13.78	0.315	BOTTOM of PANEL		D-1
A-16	A16		23.55	13.78				D-2
A-17	A17		39.5	13.78				D-3
A-18	A18		7.66	- 1.25				D-4
A-19	A19		23.55	- 1.25				D-5
A-20	A20		7.66	-13.78				D-6
A-21	A21		23.55	-13.78				D-7
A-22	A22		39.5	-13.78				D-8

TABLE V (Concluded)

CABLE NO.	ROCK-WELL NO.	SENSOR TYPE	SENSOR LOCATION, in. X FROM FRONT EDGE OF PANEL	Y FROM PAN-EL ℄ (RT-)	Z FROM PANEL IML (IML-)	PANEL Z LOCATION	TILE NO. & TYPE	TAPE RECORDER NO.
S-01	S1	CBA-13-125UW 350	35.75	-27.5	1.20	BOTTOM OF HAT SECTION		D-9
S-02	S2		43.75	-27.5				D-10
S-03	S3		35.75	27.5				D-11
S-04	S4	CBA-13-125UW 350	43.75	27.5				D-12
C-01	C1	CFC 9-16-80	41.57	-4.59	+0.003	BACK SIDE OF I.M.L.		B-1
C-02	C2		42.77	-4.08				B-2
C-03	C3		43.97	-3.56				B-3
C-04	C4		45.17	-3.03				B-4
C-05	C5		45.17	-4.56				B-5
C-06	C6		43.97	-5.06				B-6
C-07	C7		42.77	-5.60				B-7
C-08	C8		41.57	-6.11				B-8

(ESP MODULE #3)

STATIC PRESSURE TAP LOCATIONS, inches						
TOP SURFACE			BOTTOM SURFACE			
ESP PORT #	X, FROM L.E. OF AIRFOIL	Y, FROM TUNNEL ℄	ESP PORT #	X, FROM L.E. OF AIRFOIL	Y, FROM TUNNEL ℄	SECTION OF PLATFORM
1	0.00	-35		-	-35	FORWARD
2	0.552		21	0.552		
3	1.38			-		
4	2.76		22	2.76		
5	5.52			-		
6	11.04			-		
7	16.56			-		
8	27.60		23	27.60		
9	36.60			-		
10	66.24		24	66.24		
11	92.00		25	92.00		CENTER
12	110.40			-		
13	128.80		26	128.80		
14	149.04			-		
15	165.60		27	165.60		
16	187.68			-		AFT
17	204.24		28	204.24		
18	220.80			-		
19	242.88		29	242.88		
20	259.44		30	259.44		

SEE FIGURE 39

TABLE VII

LOCAL TEST CONDITIONS *

ORBITER FREESTREAM CONDITIONS			LOCAL CONDITIONS AT PANEL (X_o 450.5)		
M_∞	Q_∞ (STS-1 CYC 3)	Q_∞ / Q_{LOCAL}	M_{LOCAL}	STS-1 CYC 3 Q_L	DESIGN Q_L
0.60	389	1.164	0.67	452	495
0.80	550	1.341	1.08	738	804
0.90	610	1.273	1.25	777	853
1.05	635	1.116	1.51	708	831
1.10	635	1.074	1.54	682	816
1.15	635	1.025	1.63	651	795
1.25	640	0.971	1.66	622	778
1.40	656	0.922	1.66	605	754

* BASED ON DATA FROM IA105; $\alpha = \beta = 0^\circ$; TAP LOCATED @ X_o 450.48, $Y_o = 0$ WHICH IS COINCIDENT WITH TILE #38 ON THE 20A PANELS

TABLE VIII

TEST CONFIGURATION #20A - CALIBRATION PANEL - TEST RUN SUMMARY

		CONFIGURATION				PANEL ENVIRONMENT	
RUN NO.	DATE	MODEL	TUNNEL	SHAKER	VANES	M#	Q,PSF
1	12/13/80	BIPOD-OFF	As run with 20A Precal Panel	OFF	OFF	Vary 0.6 to 1.1	350 to 675
2	12/15/80						
3		12" BIPOD LEGS					
4	12/16/80	8" BIPID LEGS					
5							
6	12/19/80			ON			
7	12/20/80		With Vortex generators and vanes	(ON-PT.13 only)	ON Deploy (0^o to 90^o)		
8	12/31/80			OFF			400 to 750
9	1/2/81						480 to 900
10					OFF (0^o)		530 to 1,000
11	1/3/81	18" BIPOD with Sputter Plates					400 to 750
12		18" BIPOD-Sputter Plates Off					
13	1/5/81	8" BIPOD LEGS			ON		
14	1/6/81			ON	ON		
15					OFF		
16	1/7/81				ON		

TABLE IX TEST CONFIGURATION #20A TEST PANEL

TEST RUN SUMMARY

RUN NO.	DATE	OV-102 CONDITION	*WIND TUNNEL ENVIRONMENT		TIME ($Q \geq 500$)	REMARKS
1	1/19/81	STS-1 LIMIT	M=.6-1.1	Q=400-750 PSF	4 MIN.	STS-1 COMPLETE
2	1/19/81	STS-1 LIMIT	M=.6-1.1			NO TEST
3	1/20/81	STS-1 LIMIT	M=.6-1.1		6 MIN.	
4	1/21/81	STS-1 LIMIT	M=.6-1.1	Q=400-750 PSF	7 MIN.	
5	1/21/81	DESIGN LIMIT	M=.6-1.1	Q=480-900 PSF	4.7 MIN.	
6	1/22/81	DESIGN LIMIT	M=.6.1.1		10.5 MIN.	
7	1/23/81	DESIGN LIMIT	M=.6-.1.1	Q=480-900 PSF	28 MIN.	
8	1/23/81	DESIGN LIMIT	M=.6-1.1	Q=480-900 PSF	28 MIN.	
9	1/24/81	DESIGN LIMIT	M=.6-1.1	Q=480-900 PSF	28 MIN.	
				TOTAL	116 MIN. 58 MISSIONS** 232 CYCLES	

*AERO SHOCK PLUS SHAKER VIBRATION

**SCATTER FACTOR OF 4

TABLE X

CLOT - NOSE LANDING GEAR DOOR - TEST CONFIGURATION #20C

TEST RUN SUMMARY

RUN NO.	DATE	OV 102 CONDITION	WIND TUNNEL ENVIRONMENT	TIME ($Q \geq 500$)	REMARKS
1	3/26/81	DESIGN LIM	M=.60-1.76 Q=415-867 PSF	1 MIN	
2	3/27/81			3 MIN	STS-1 COMPLETE
3	3/28/81			12 MIN	THERMAL BARRIER FRAYING
4	3/28/81			20 MIN	
5	3/30/81			32 MIN	
6	3/30/81			36 MIN	
7	3/30/81			3 MIN	
8	3/31/81	DESIGN LIM	M=.60-1.76 Q=415-867 PSF	37 MIN	
			TOTAL	144 MIN 144 CYCLES 36 MISSION EQUIVALENTS*	

*SCATTER FACTOR OF 4

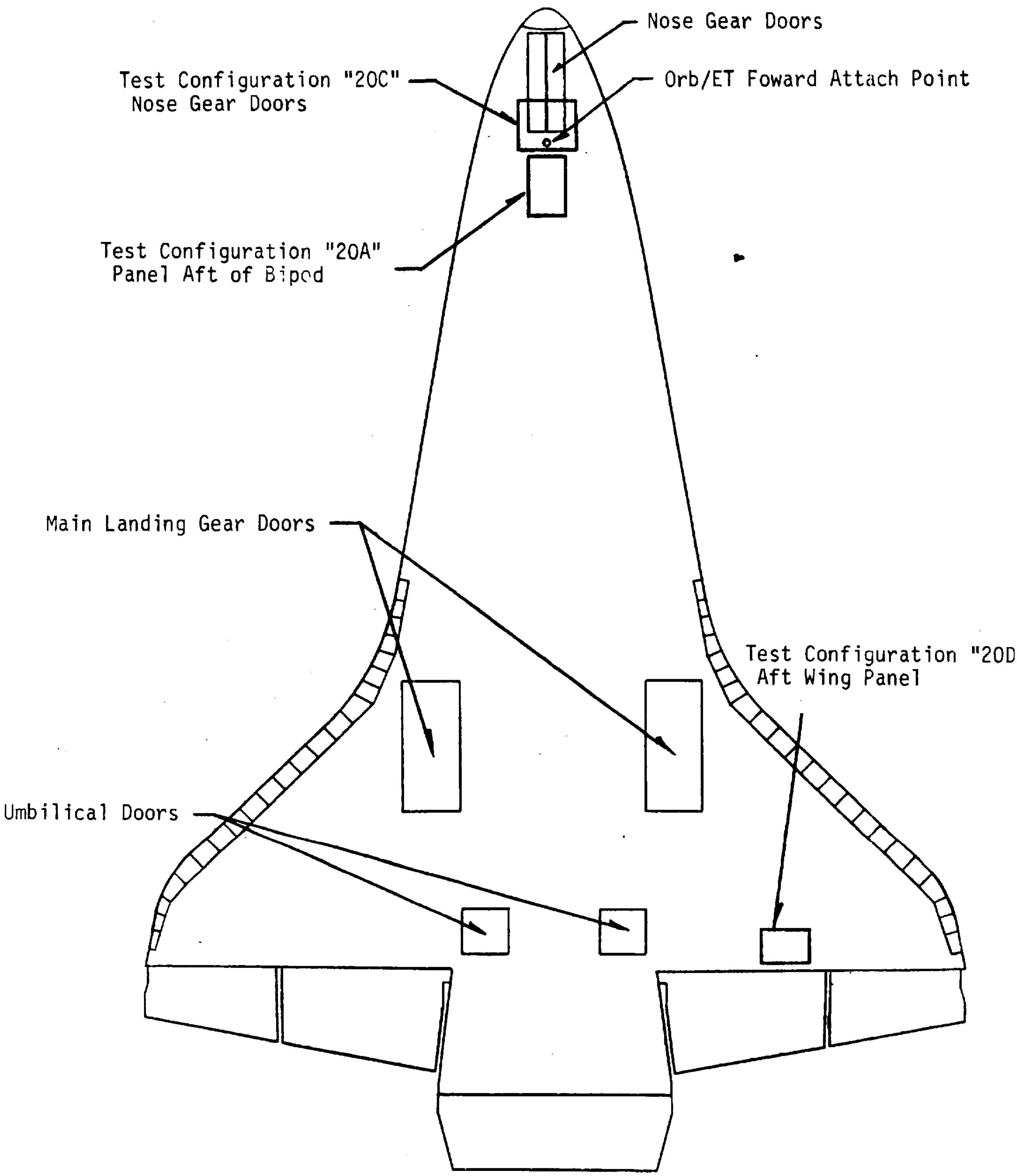


Figure 1. Test Configuration Locations

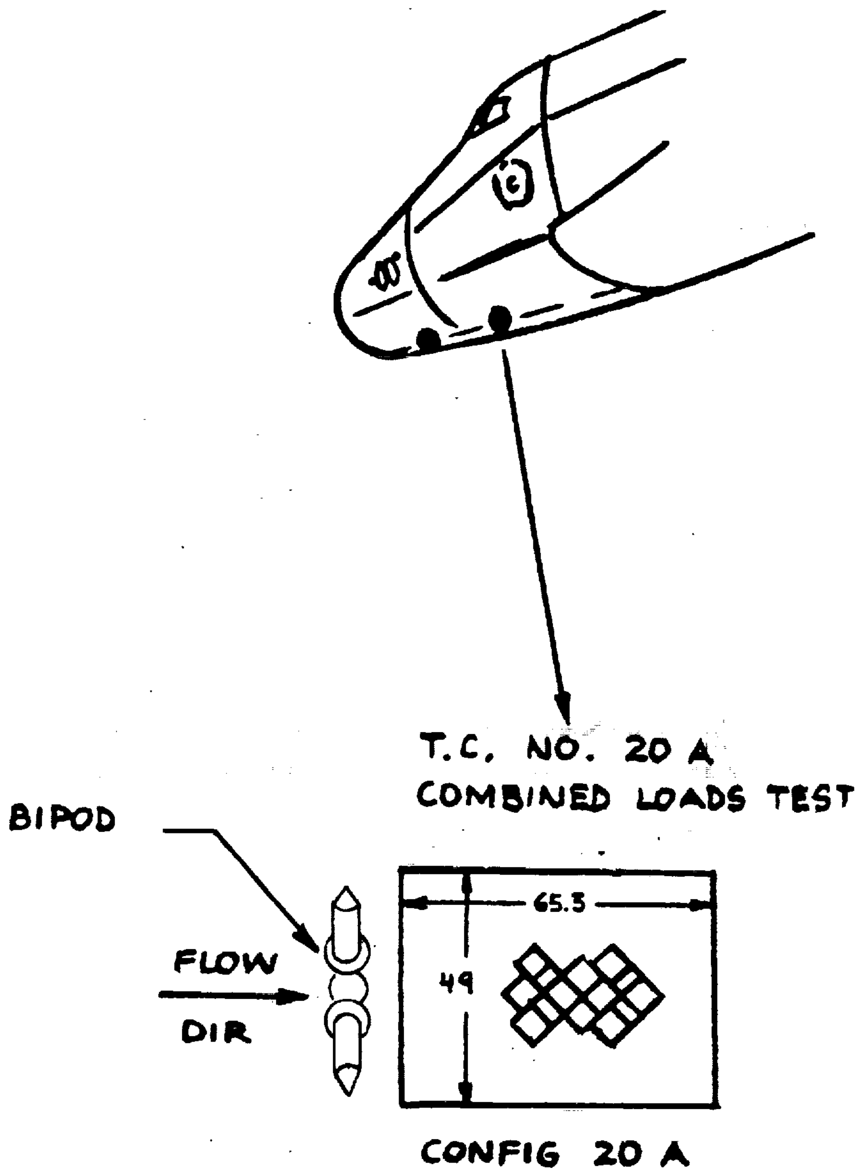
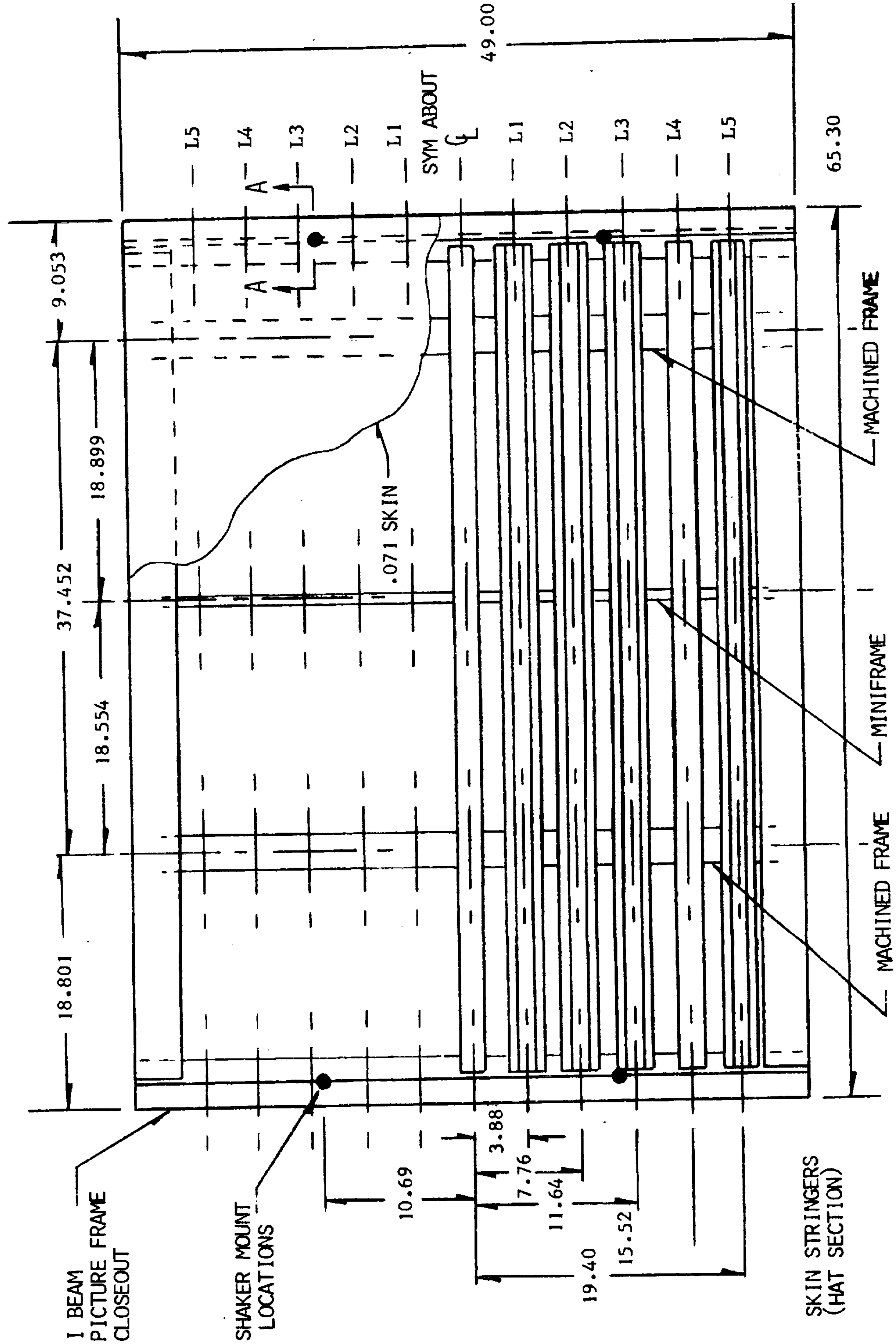


Figure 2. Test Configuration 20A
General Arrangement



49.00
65.30
SYM ABOUT ℄
L1
L2
L3
L4
L5
A
A
9.053
18.899
37.452
18.554
18.801
.071 SKIN
MACHINED FRAME
MINIFRAME
MACHINED FRAME
3.88
7.76
11.64
15.52
19.40
10.69
I BEAM
PICTURE FRAME
CLOSEOUT
SHAKER MOUNT
LOCATIONS
SKIN STRINGERS
(HAT SECTION)

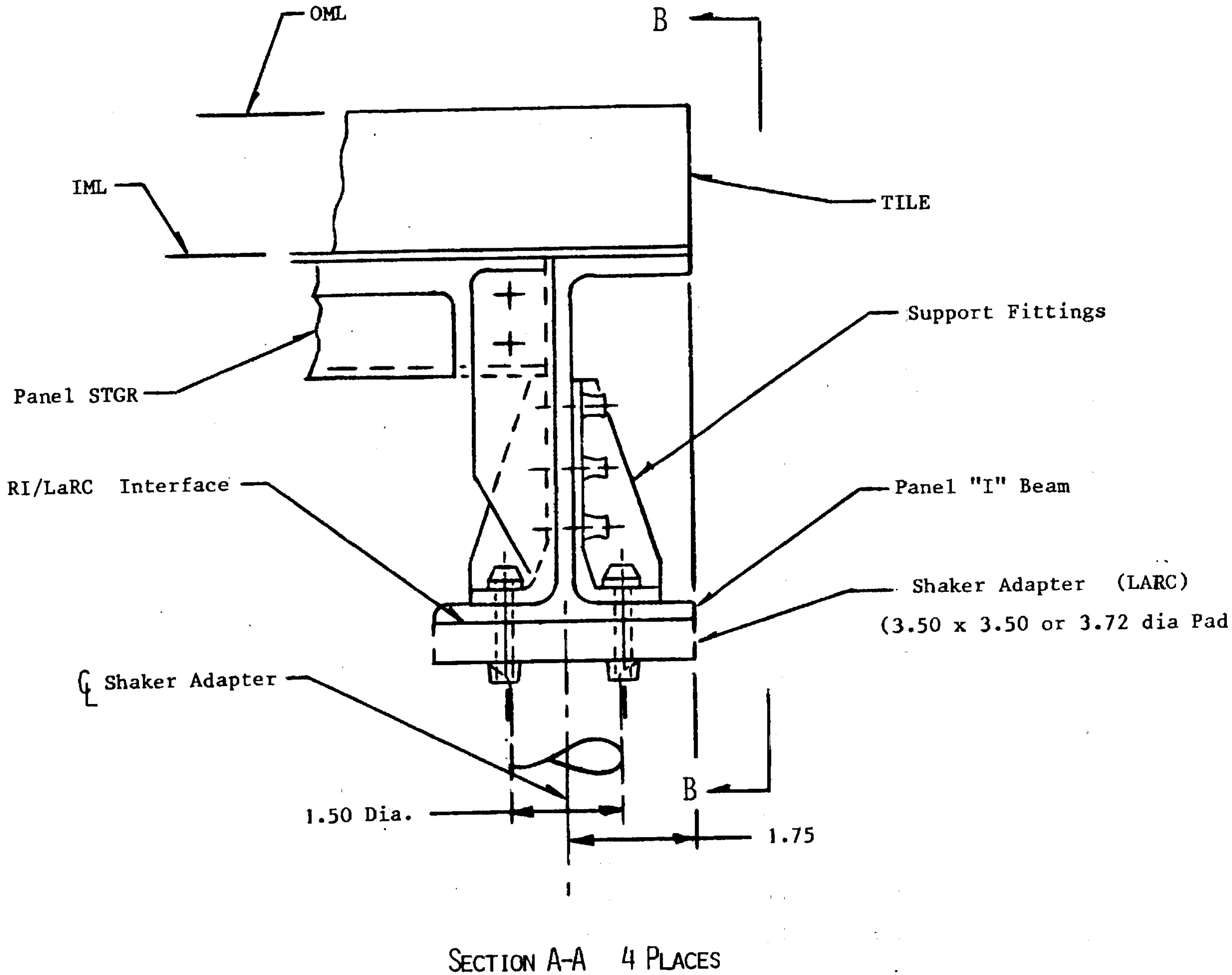


Figure 4a. Test Configuration 20A
Shaker Supports

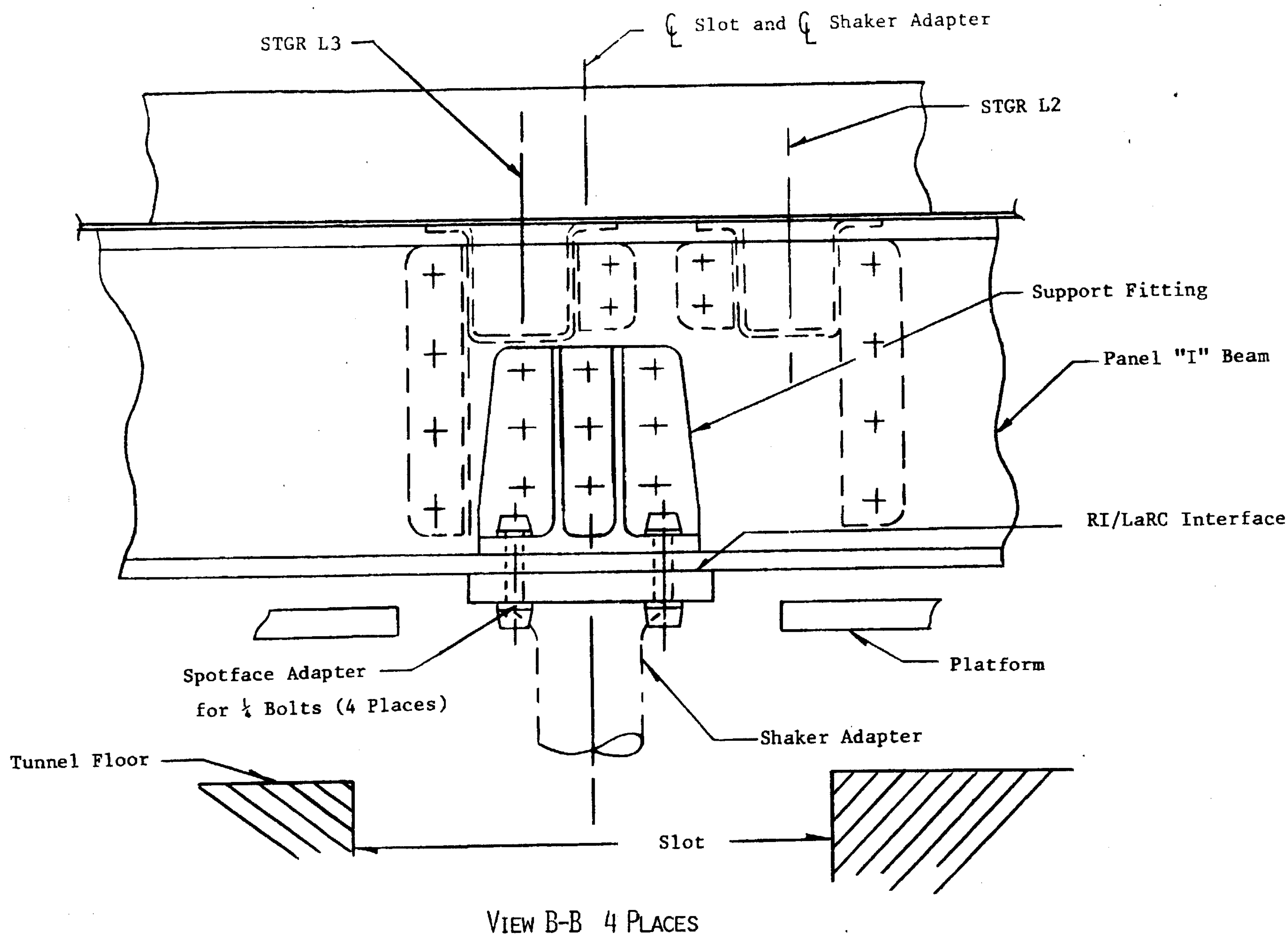


Figure 4b. Test Configuration 20A
Shaker Supports

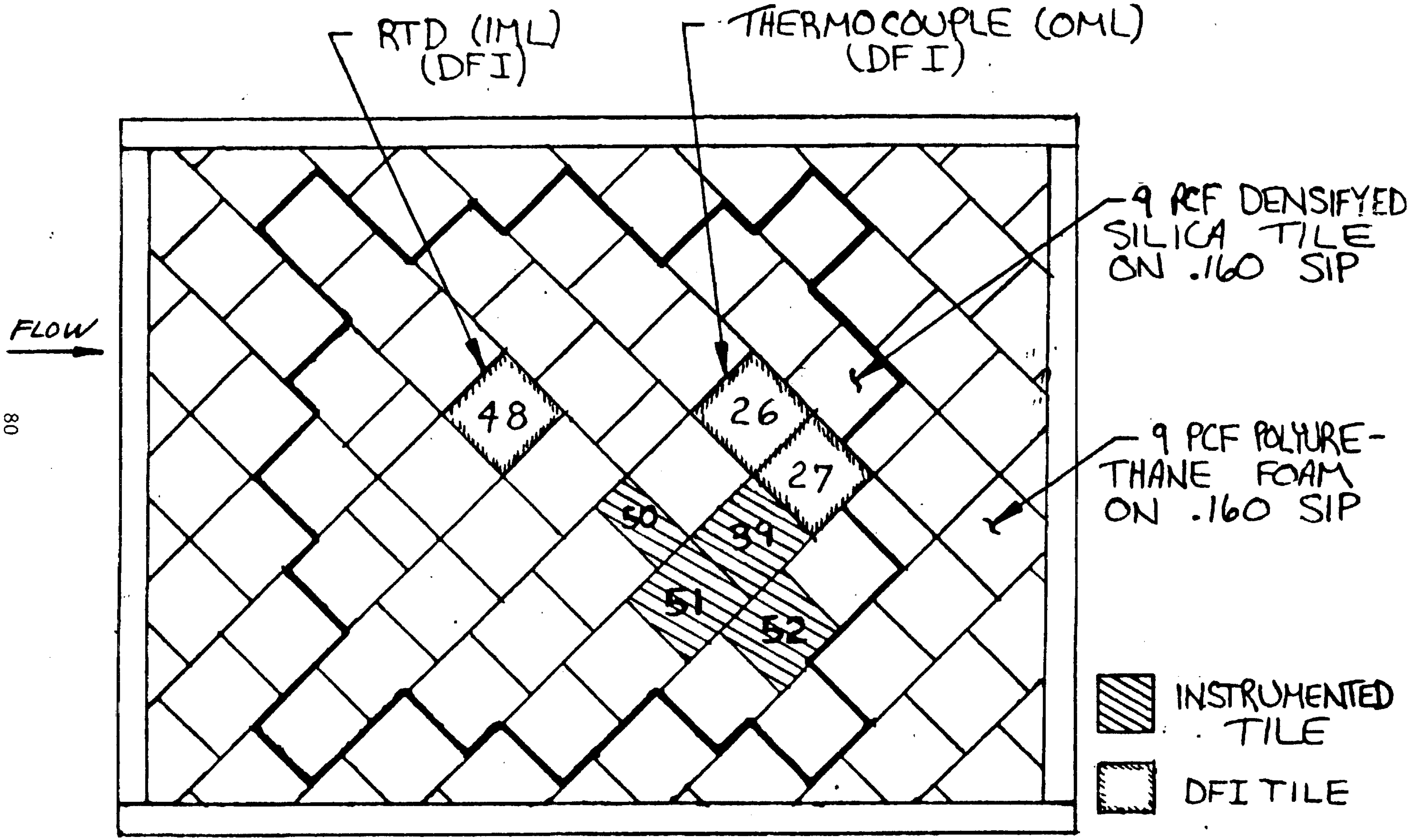


Figure 5. 20A Test Panel TPS Arrangement

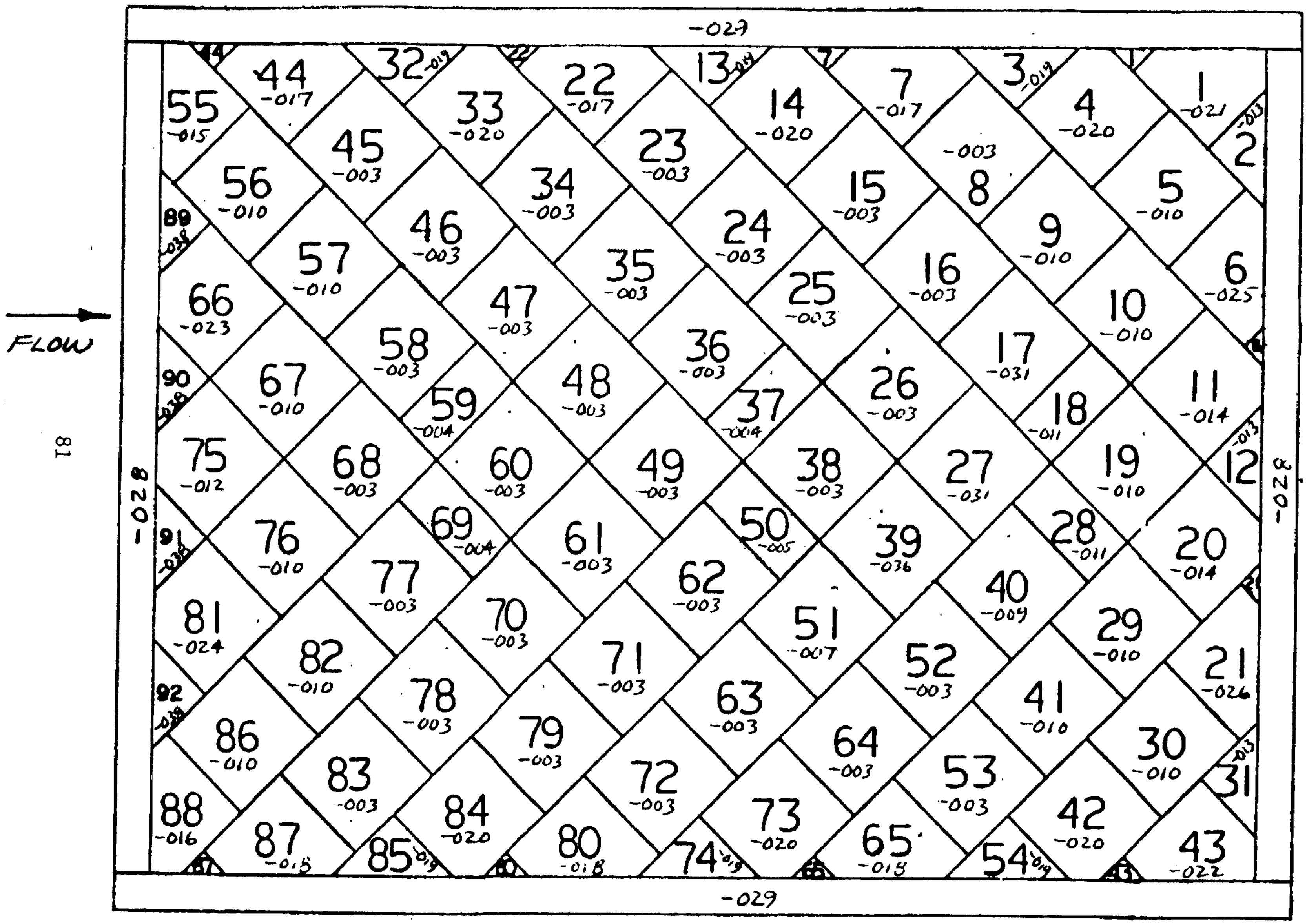


Figure 6. 20A Test Panel Identification Numbers

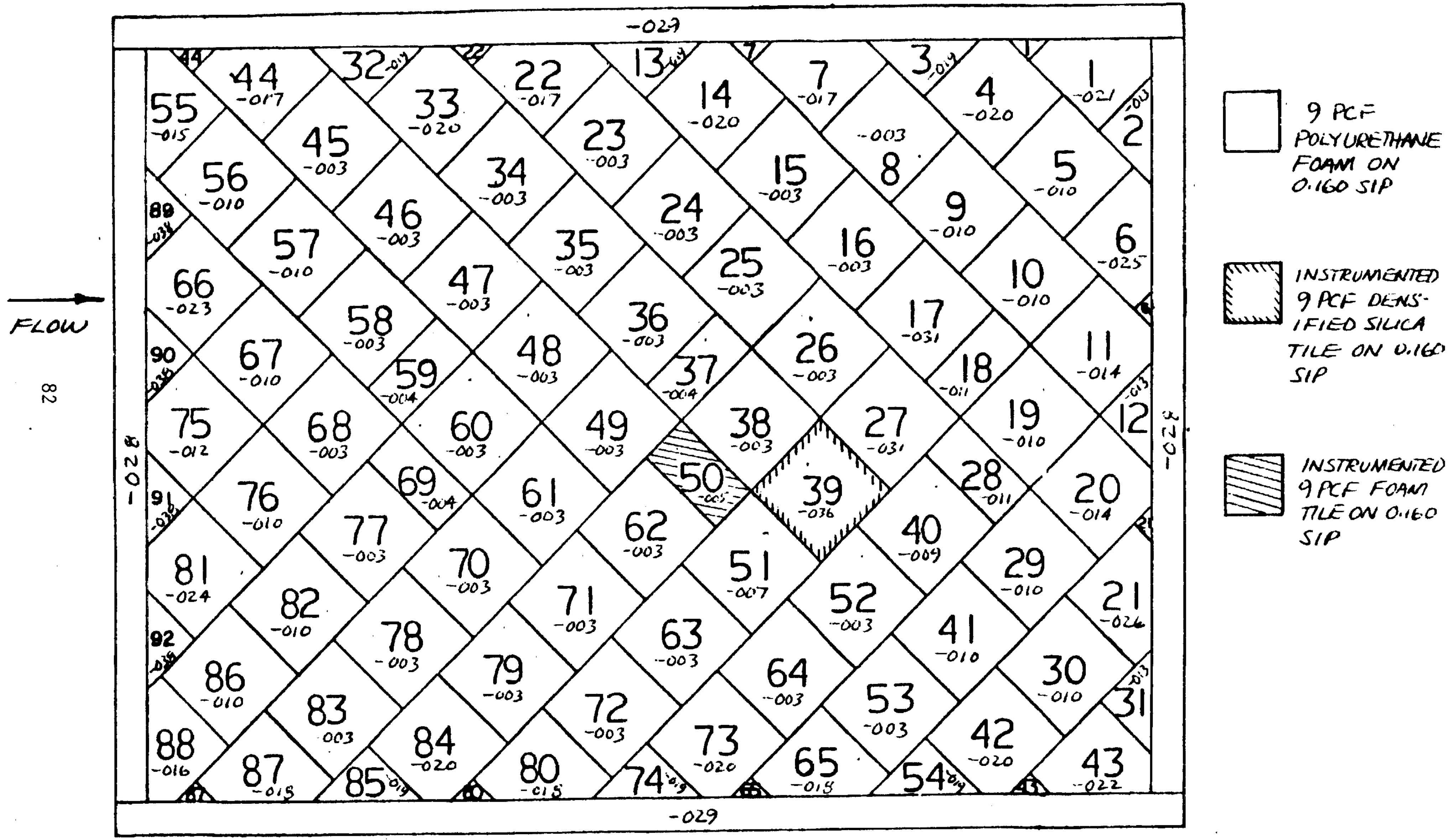


Figure 7. 20A Calibration Panel TPS Arramgement and Identification Numbers

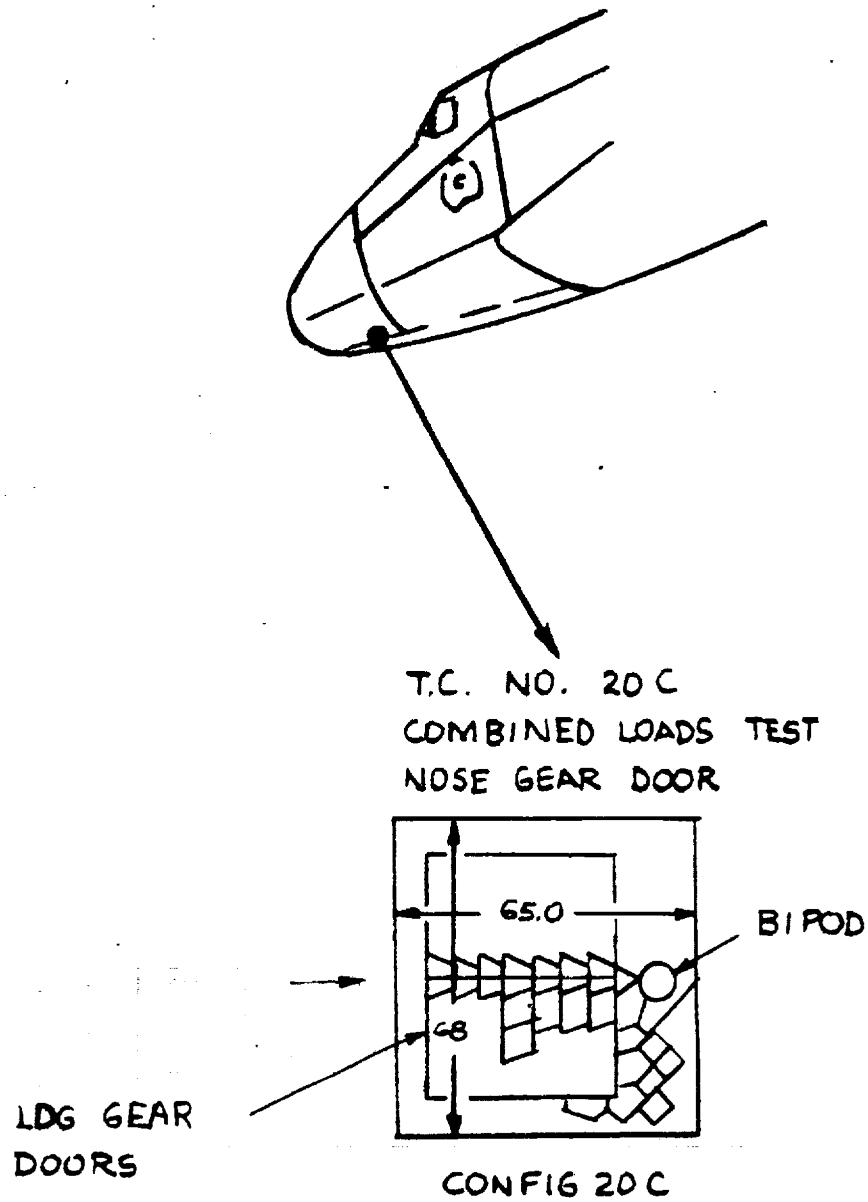


Figure 8. Test Configuration 20C
General Arrangement

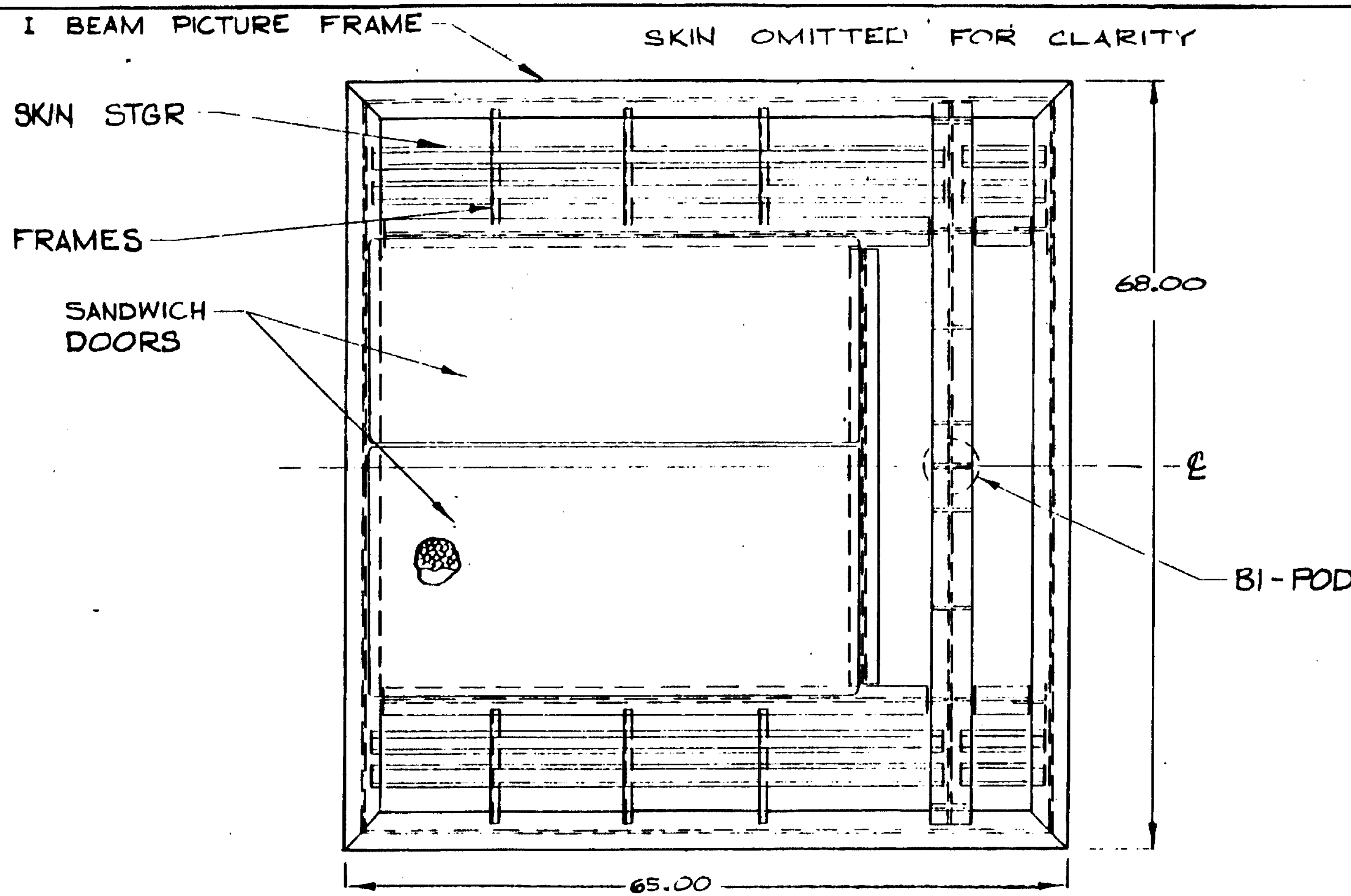


Figure 9. Test Panel 20C Structure

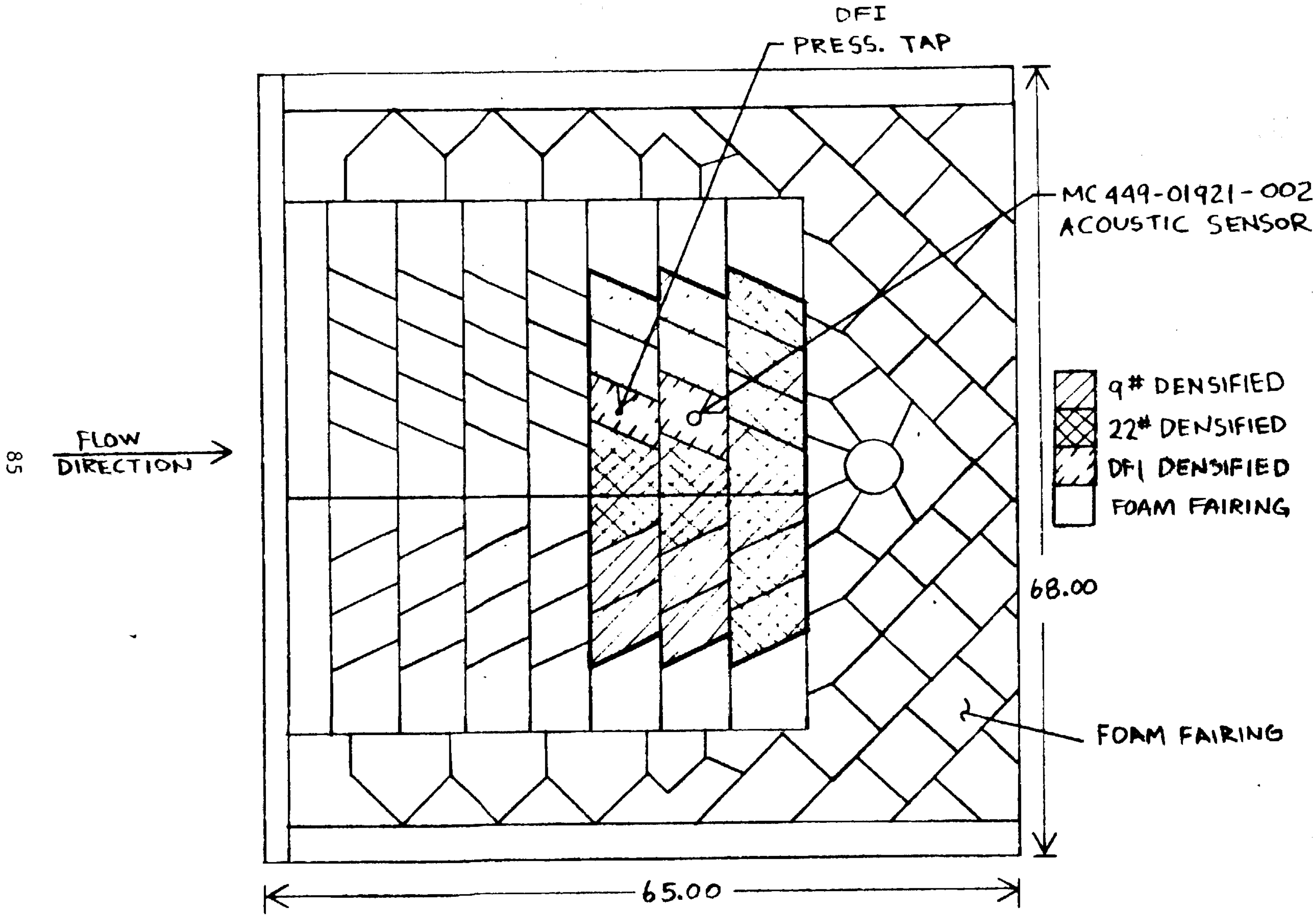


Figure 10. Test Panel 20C TPS Arrangement

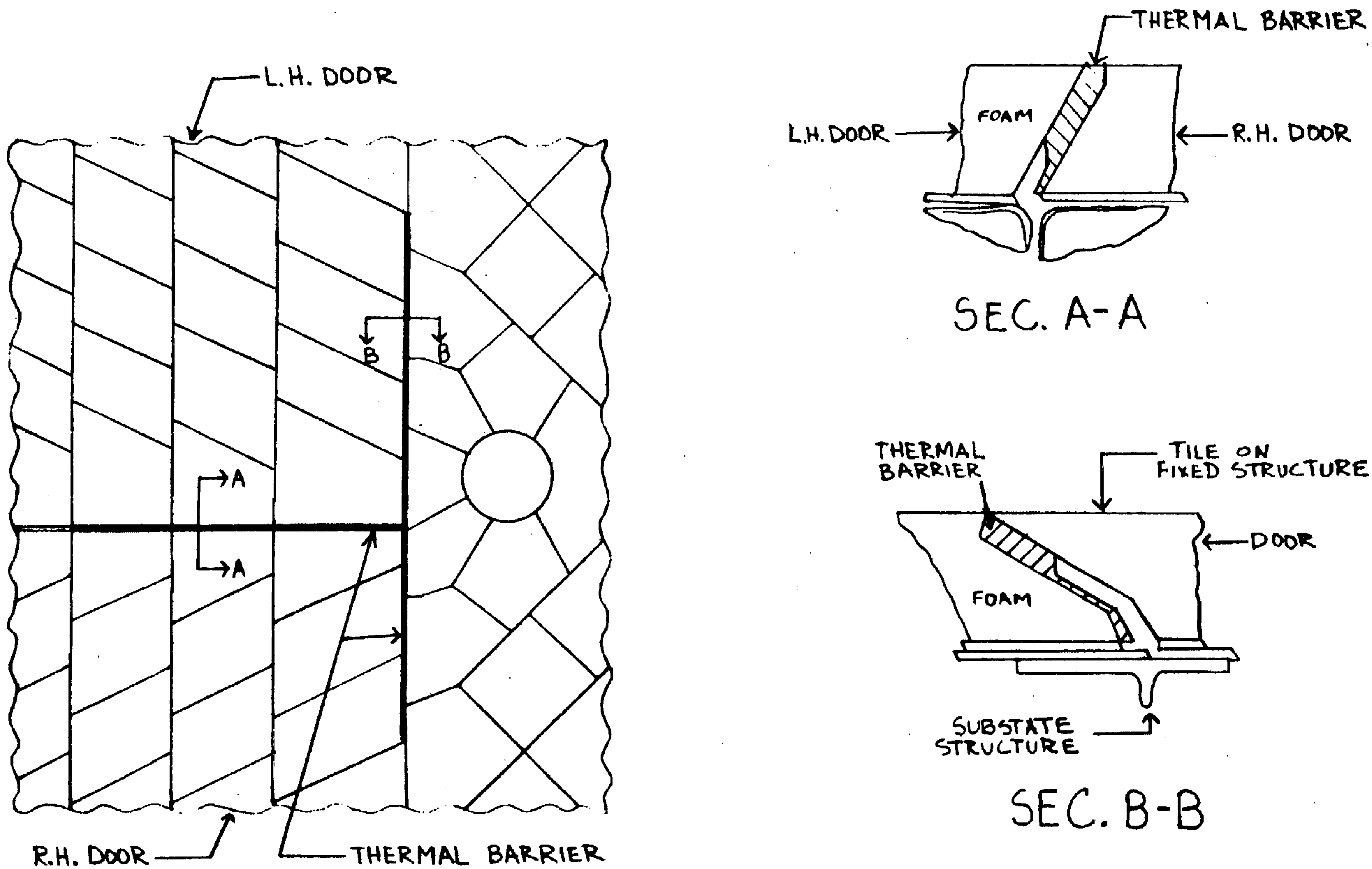


Figure 11. Test Panel 20C Nose Gear Door Thermal Barrier

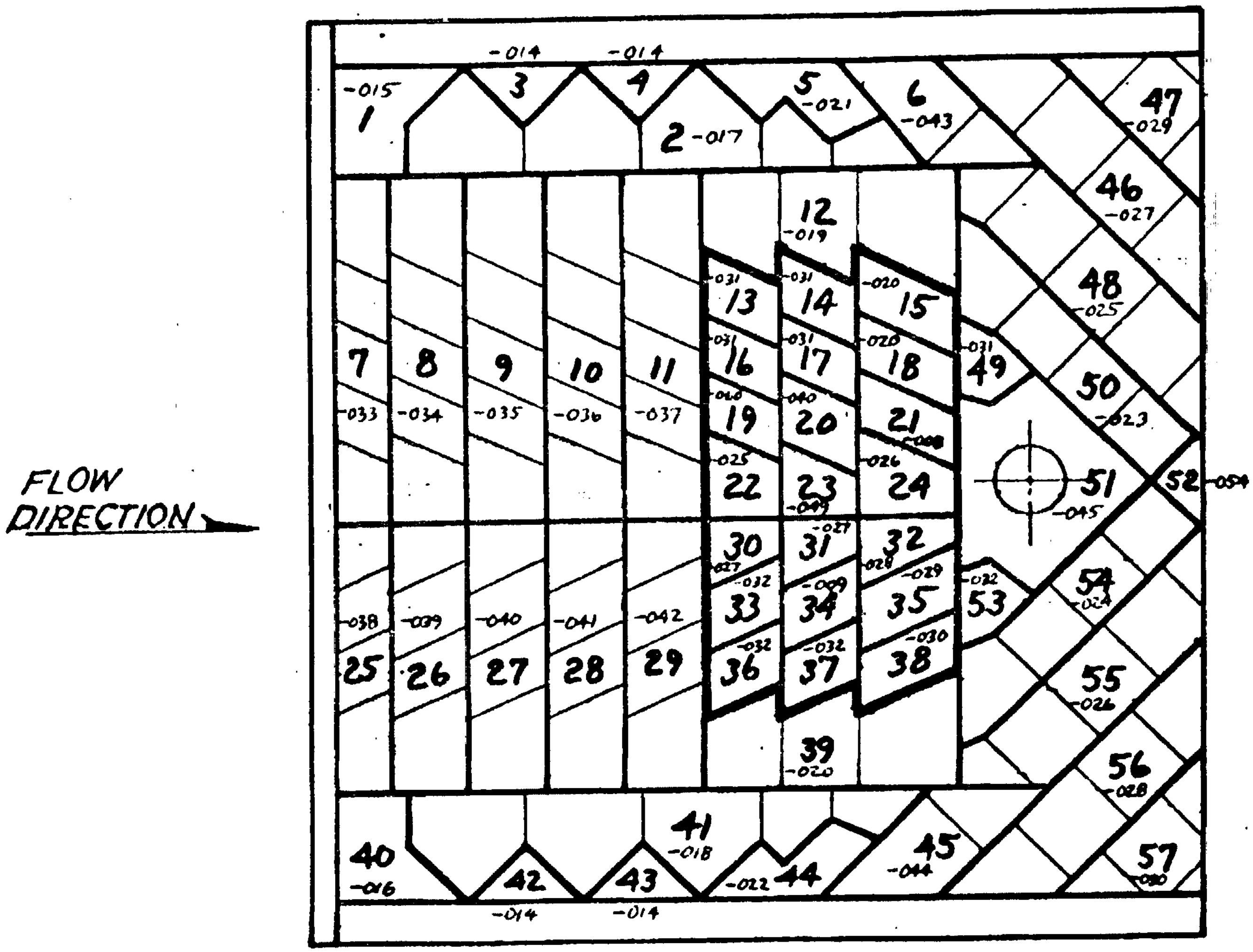


Figure 12. Test Panel 20C Tile Identification Numbers

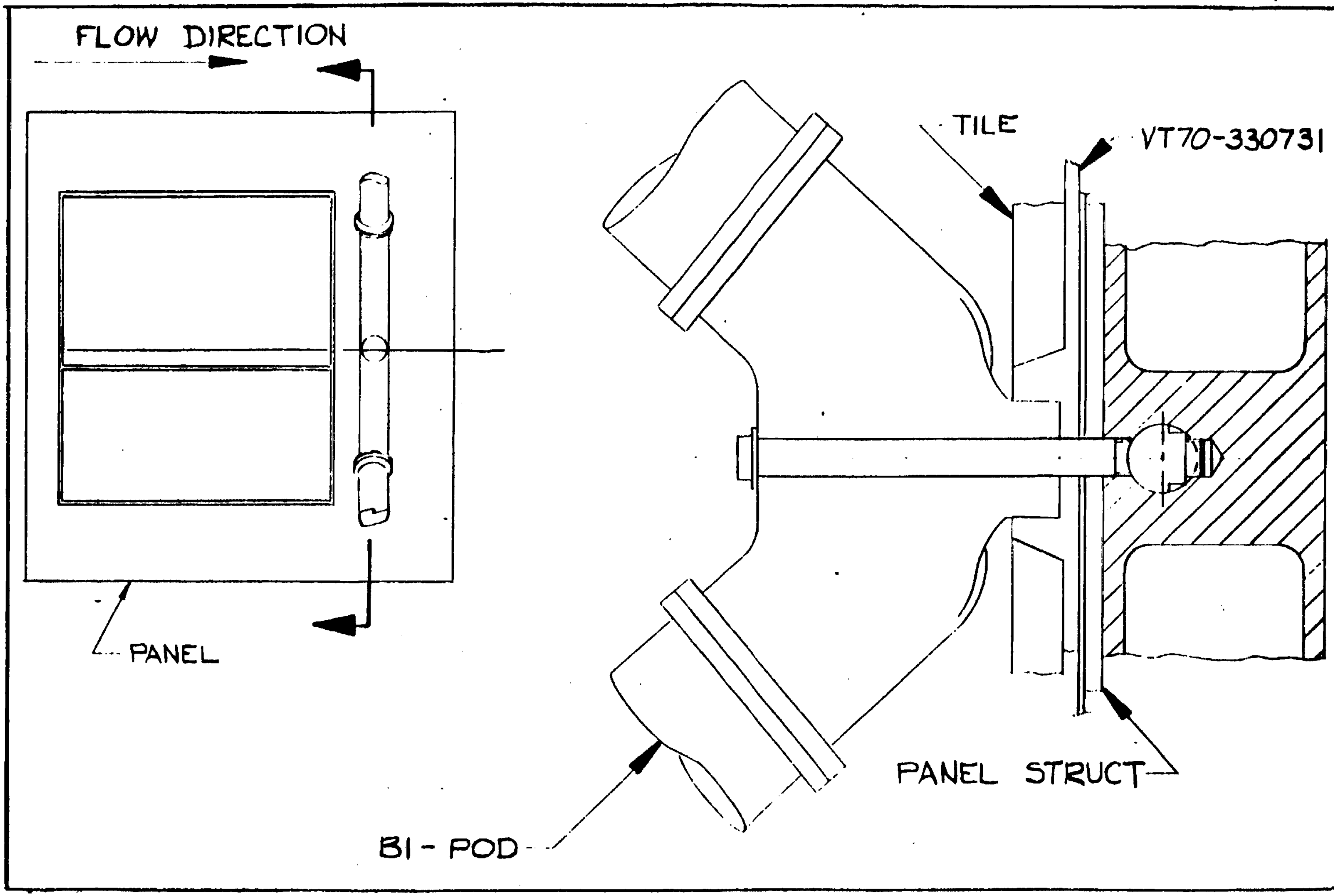


Figure 13. Test Panel 20C Bipod Attach

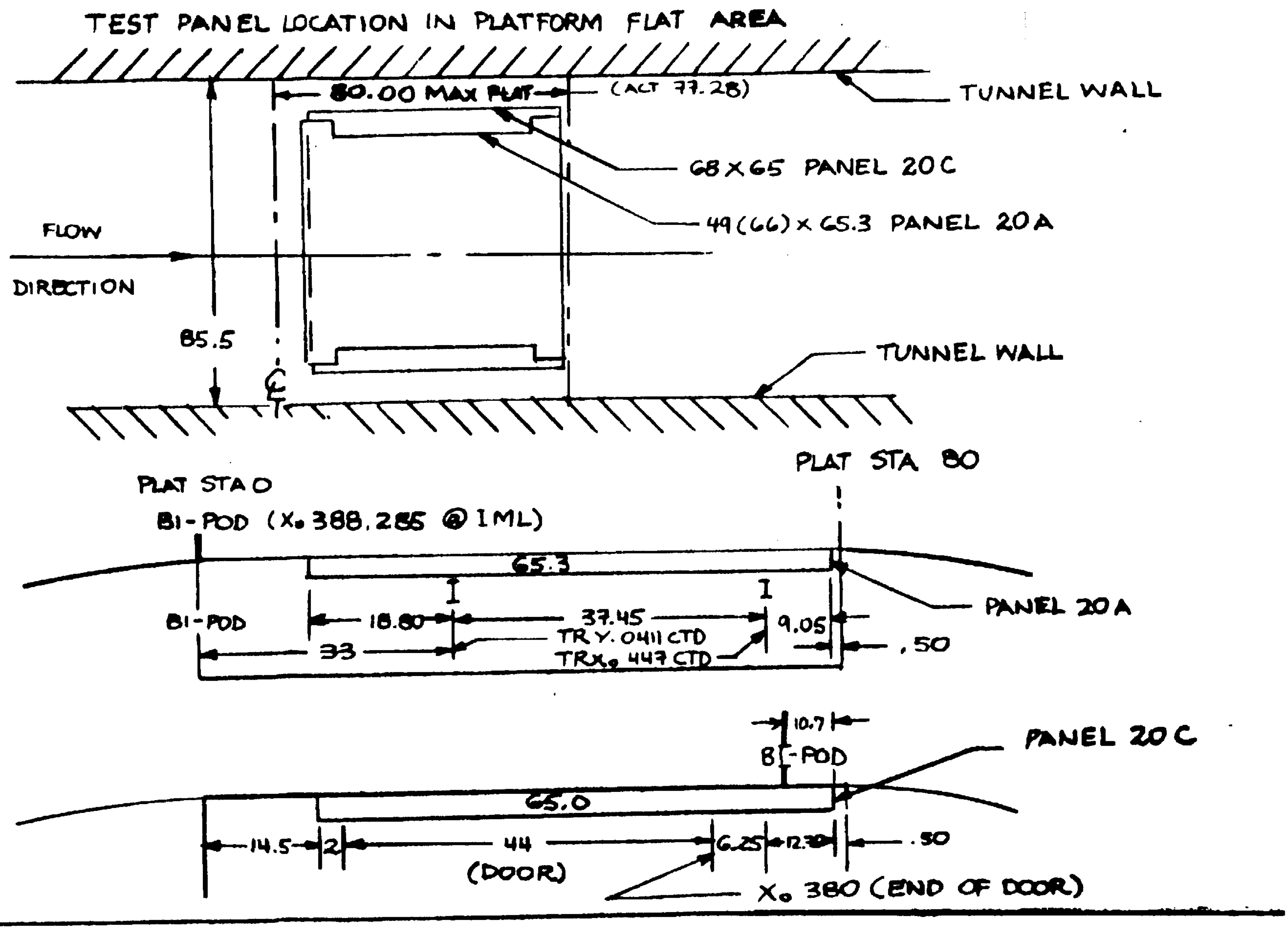


Figure 14. Panel/Platform Relationships

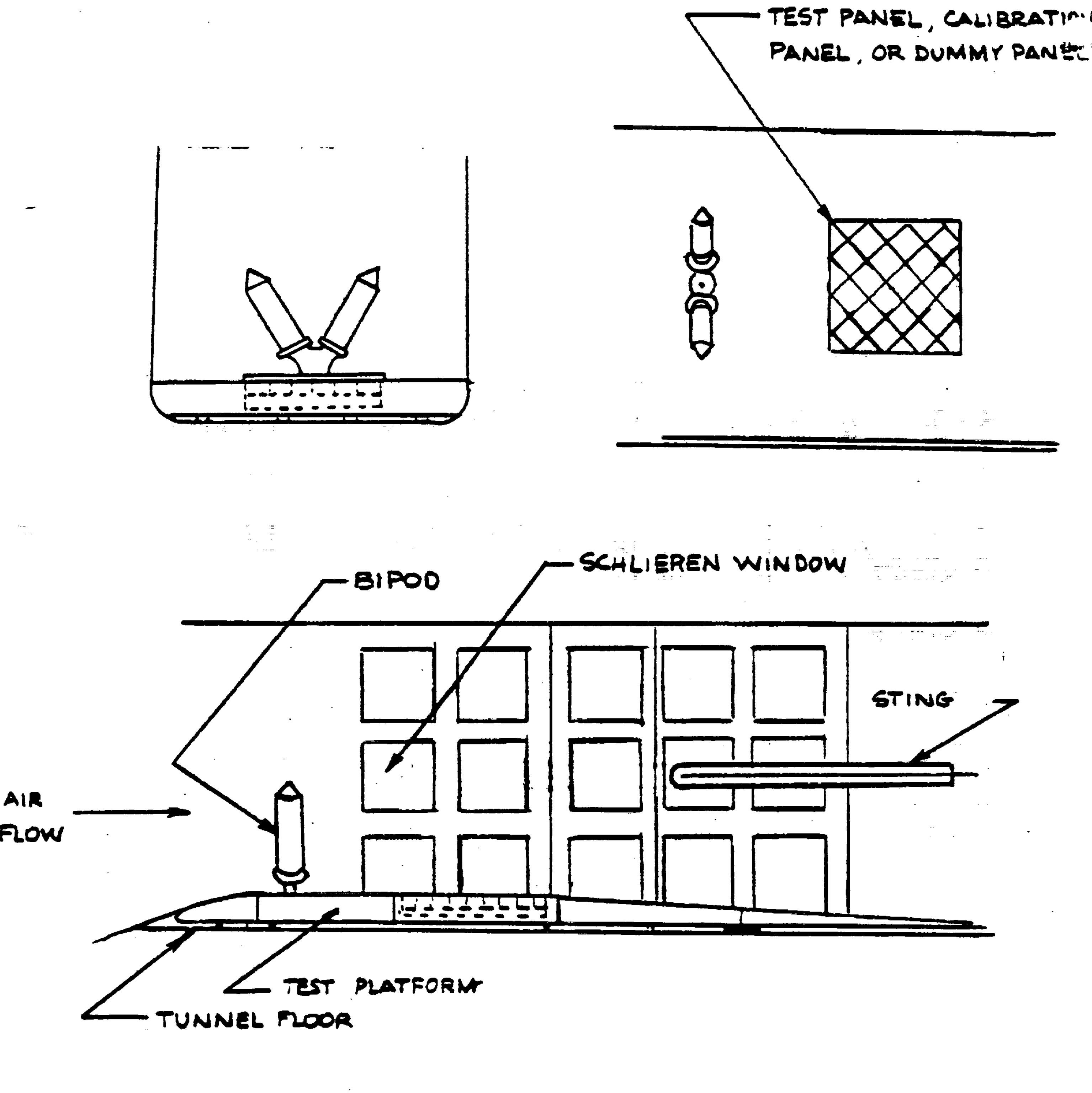


Figure 15. Test Configuration 20A, Forward Bipod Position

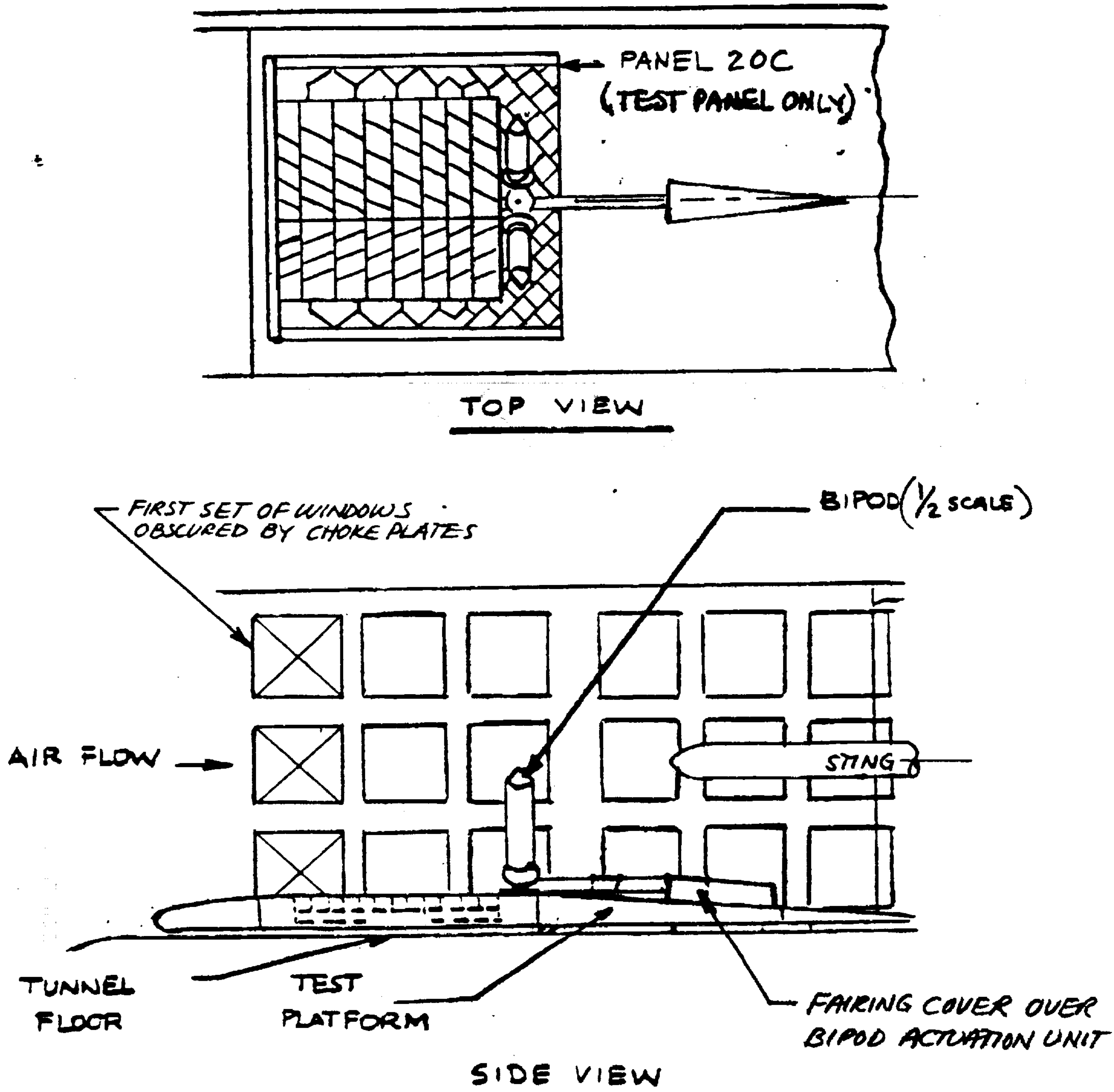
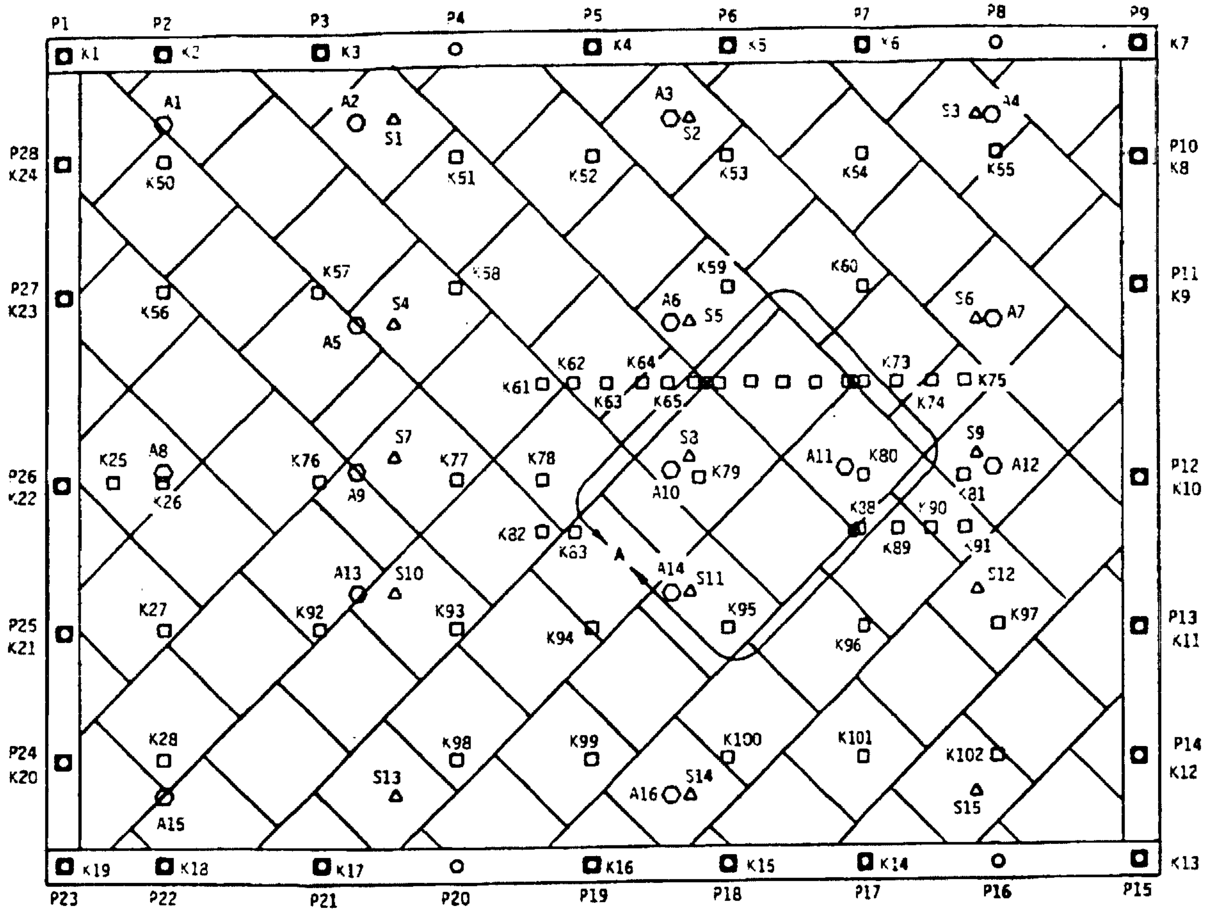


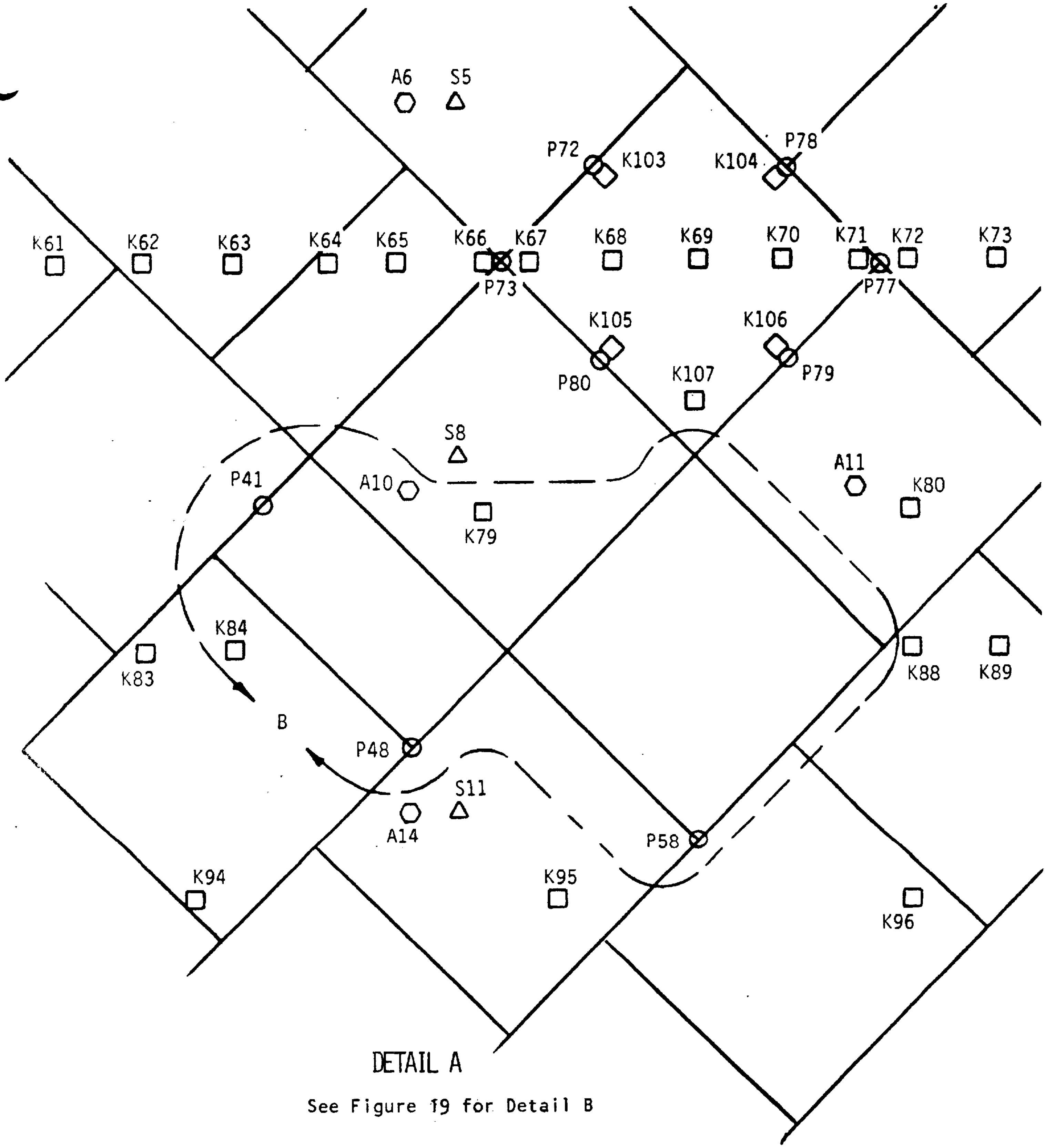
Figure 16. Test Configuration 20C Aft Bipod Position



84	Kulites (Absolute)
25	Kulites (Differential)
51	Pressure Tubes
26	Accelerometers
15	Strain Gages
201	TOTAL

See Figure 18 for Detail A

Figure 17. 20A Calibration Panel Instrumentation



DETAIL A

See Figure 19 for Detail B

Figure 18. 20A Calibration Panel Instrumentation (Detail A)

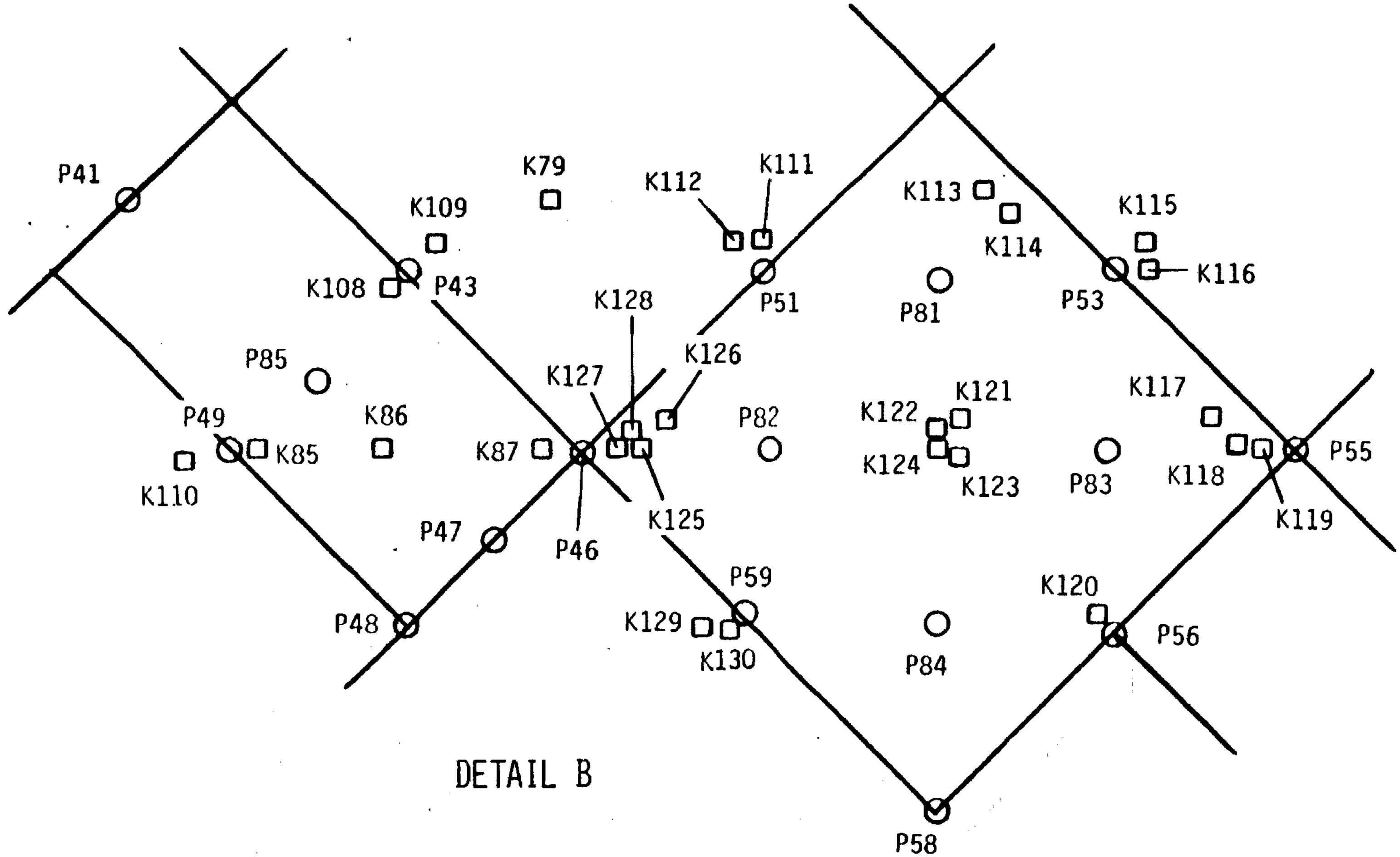
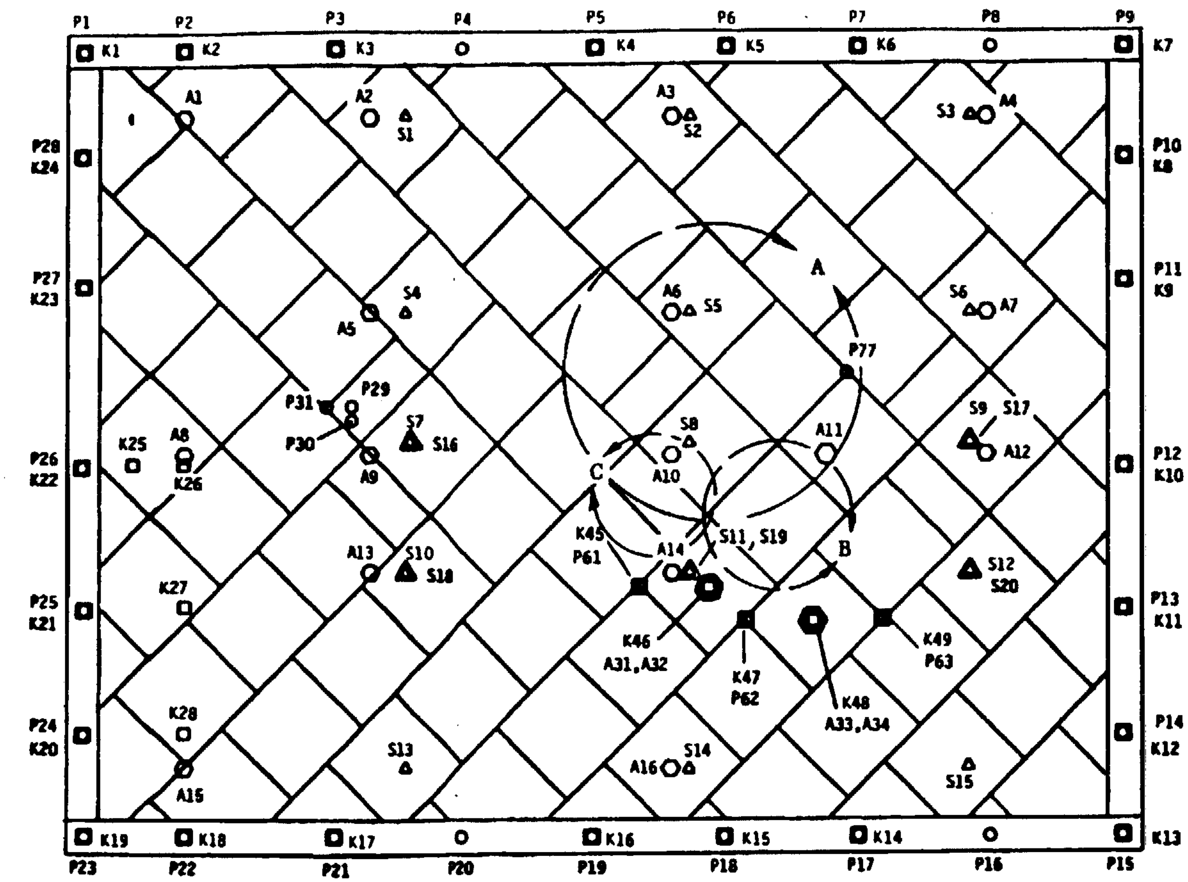


Figure 19. 20A Calibration Panel (Detail B)
Kulite Tile



6 Kulites (Absolute)
43 Kulites (Differential)
77 Pressure Tubes
4 Deflectometers
48 Accelerometers
12 Coe Loaded Cells
20 Strain Gages

---

210 TOTAL

See Figure 21 for Detail A
See Figure 22a for Detail B
See Figure 23 for Detail C

Figure 20. 20A Test Panel Instrumentation

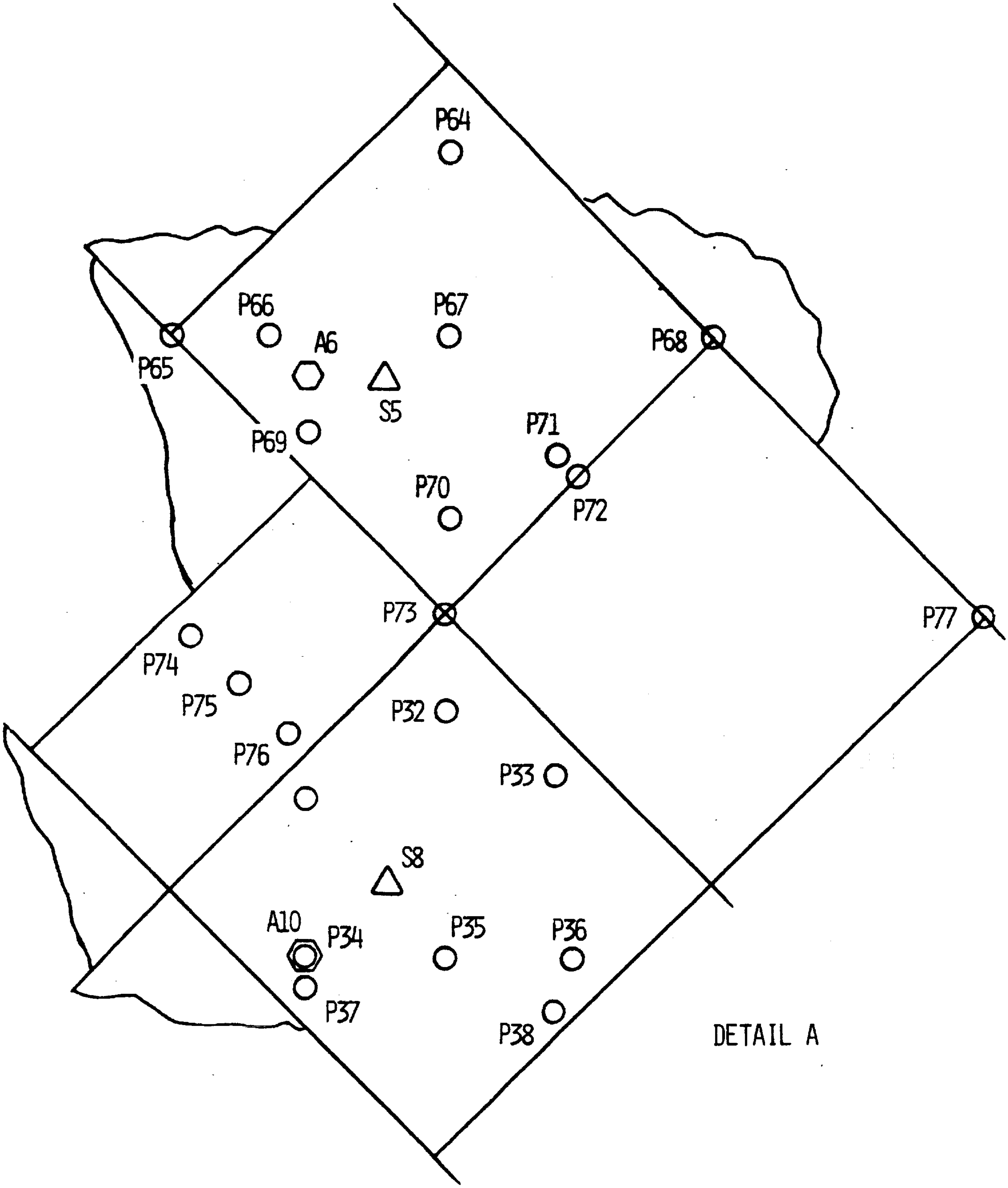


Figure 21. 20A Test Panel Instrumentation
(Detail A)

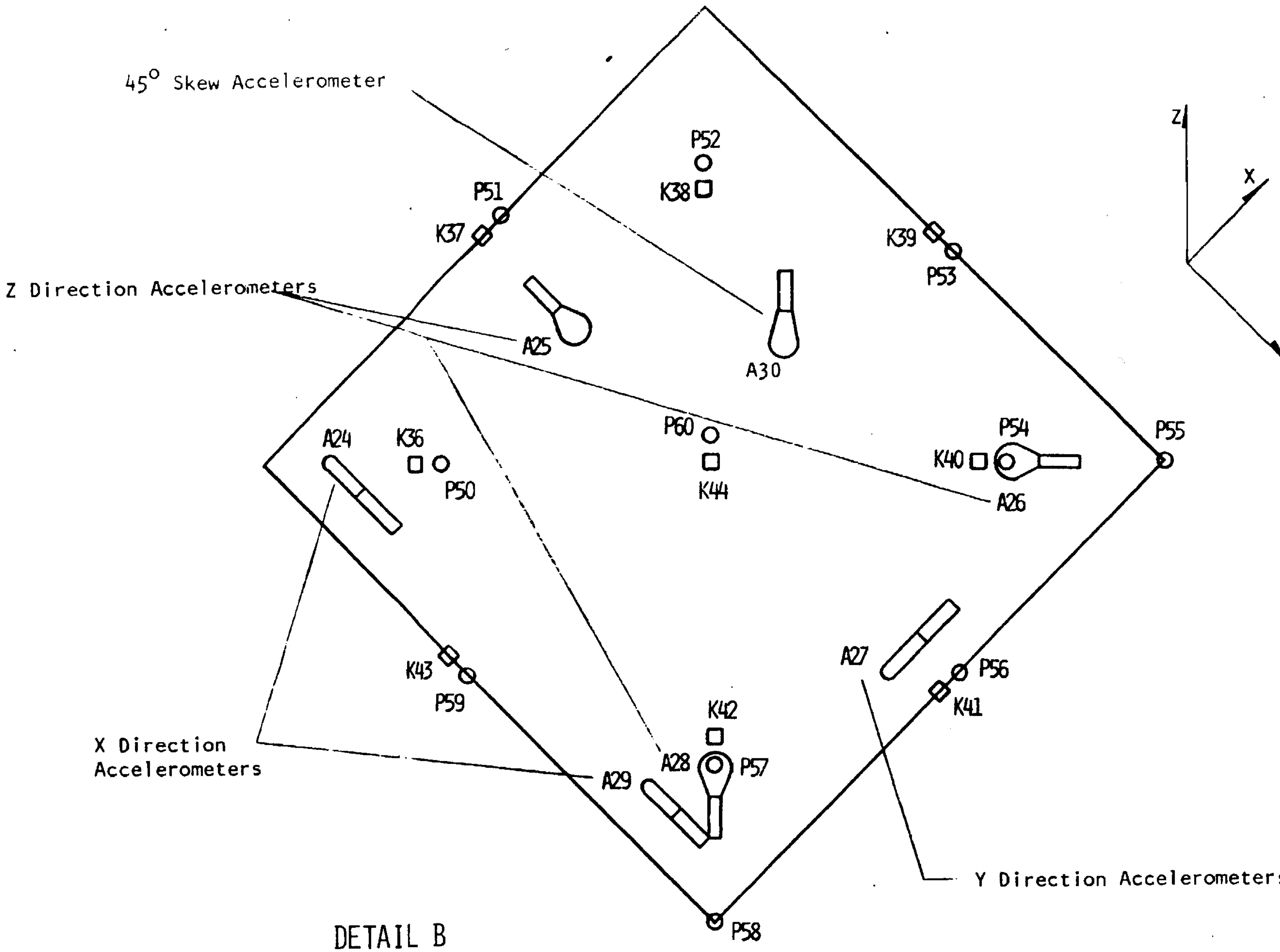


Figure 22. 6 x 6 Instrumented Tile Test Panel 20A (Detail B)

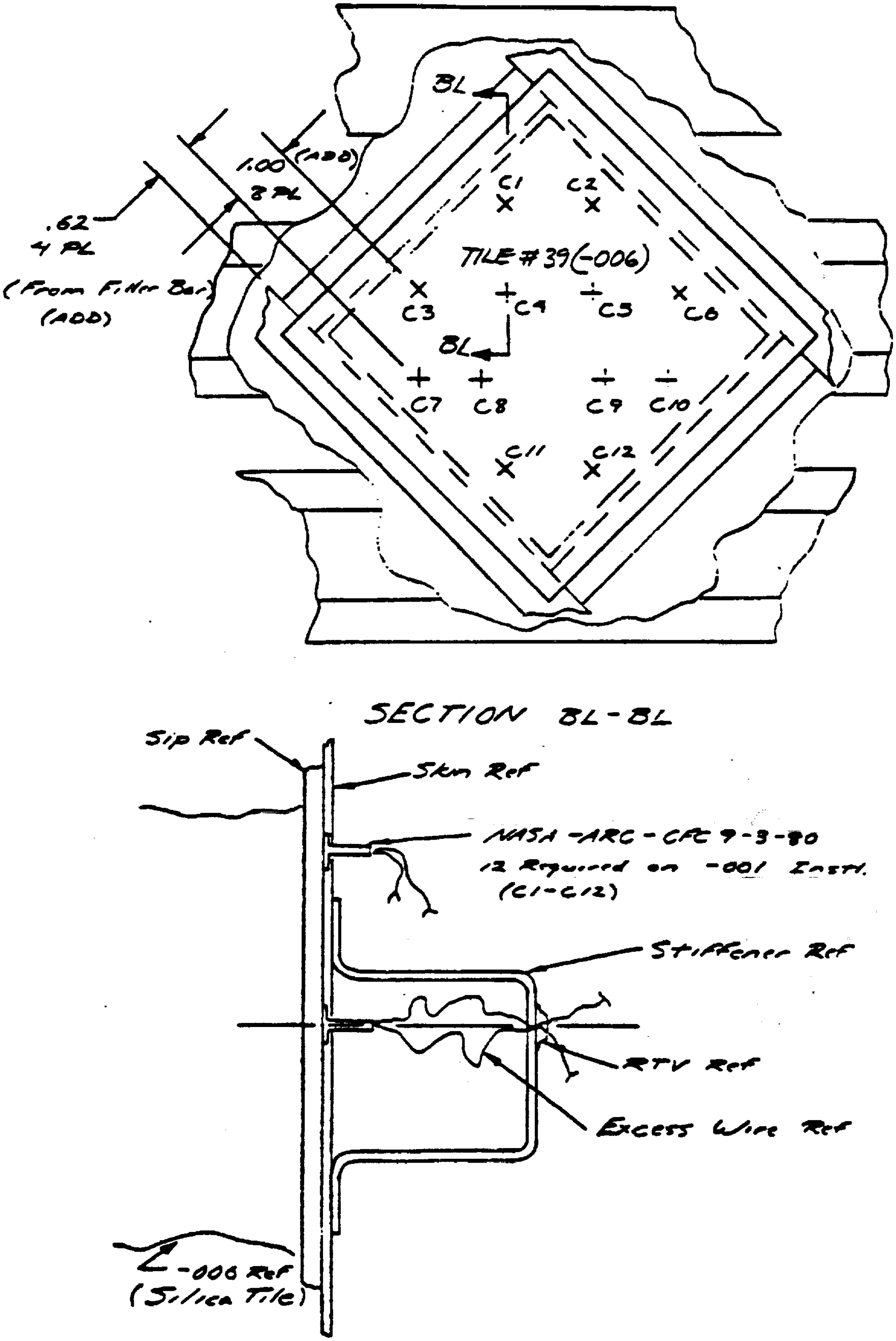
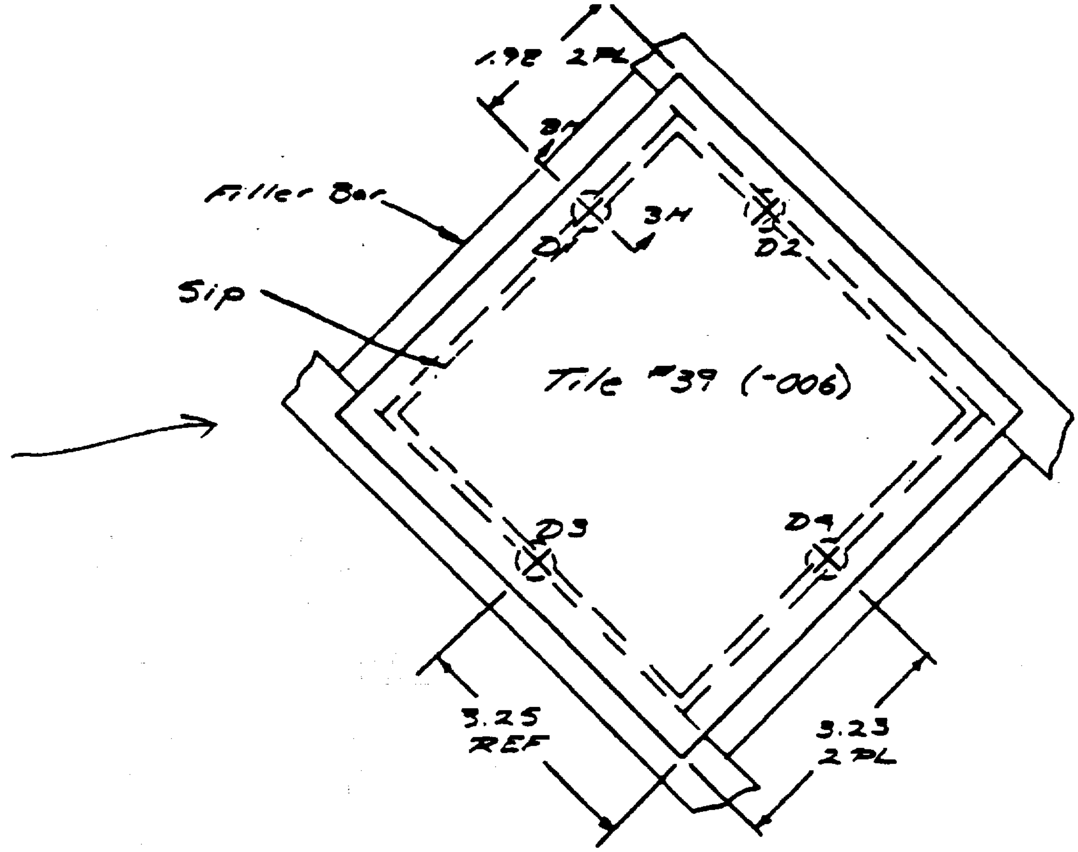


Figure 23 . ARC "Coe" Tile Balance Inst.
Test Panel 20A



SECTION 8H-8H

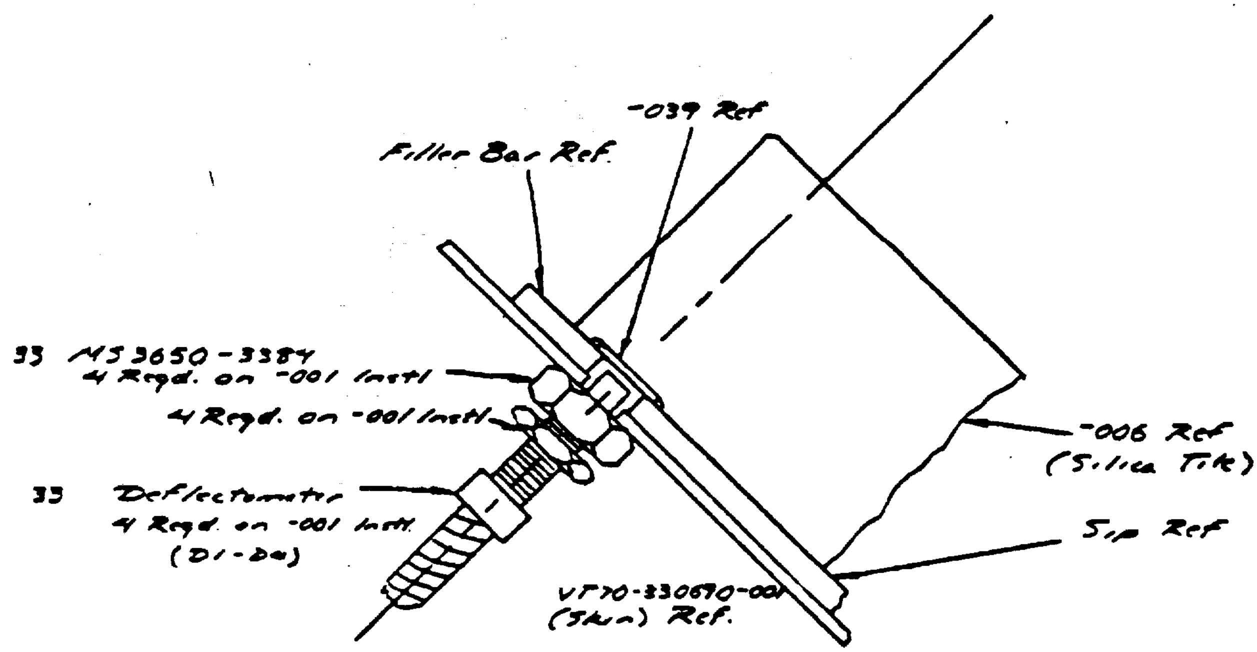


Figure 24. "Bently" Deflectometer Inst.
Test Panel 20A

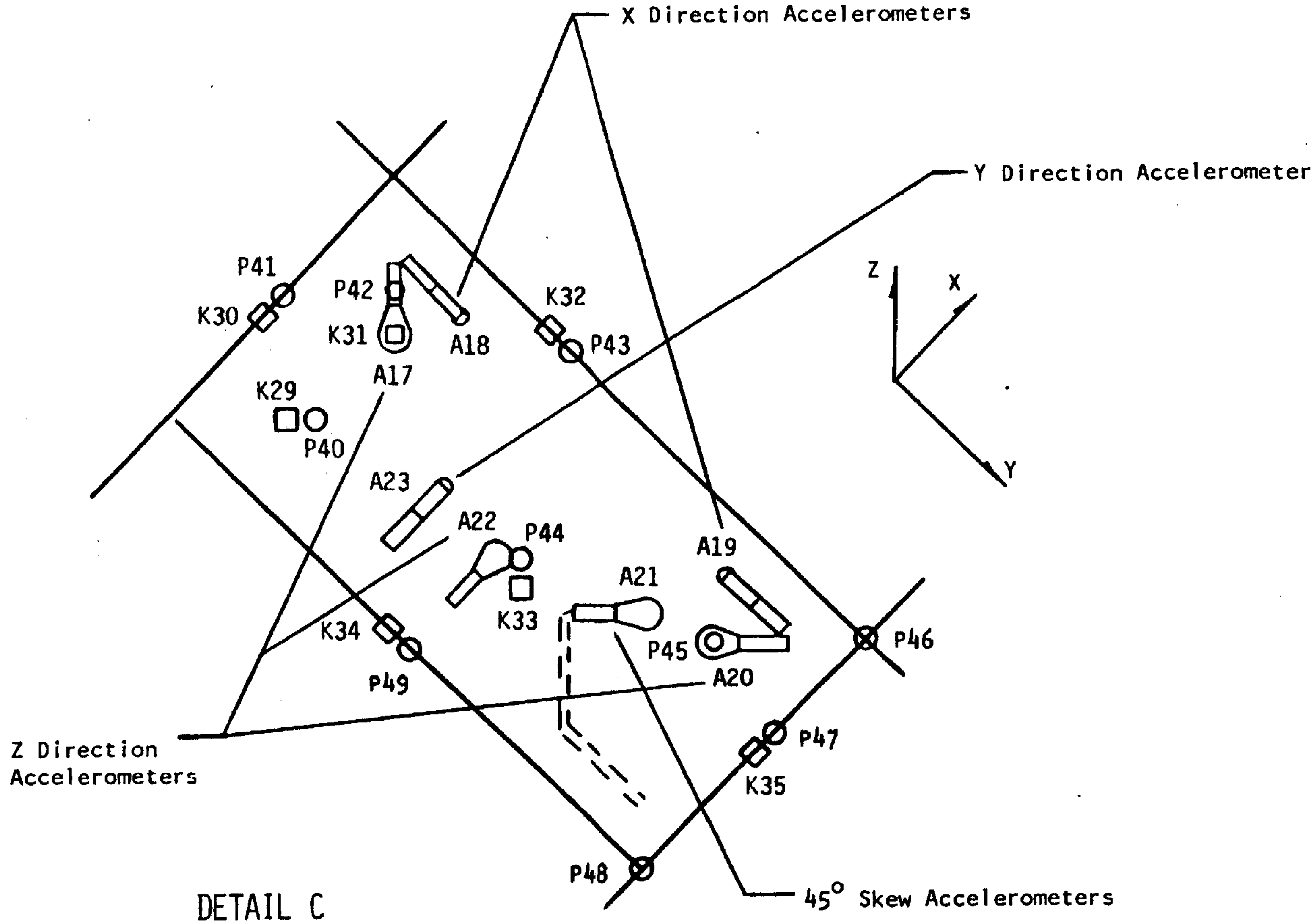


Figure 25. 3 x 6 Instrumented Tile Test Panel 20A (Detail C)

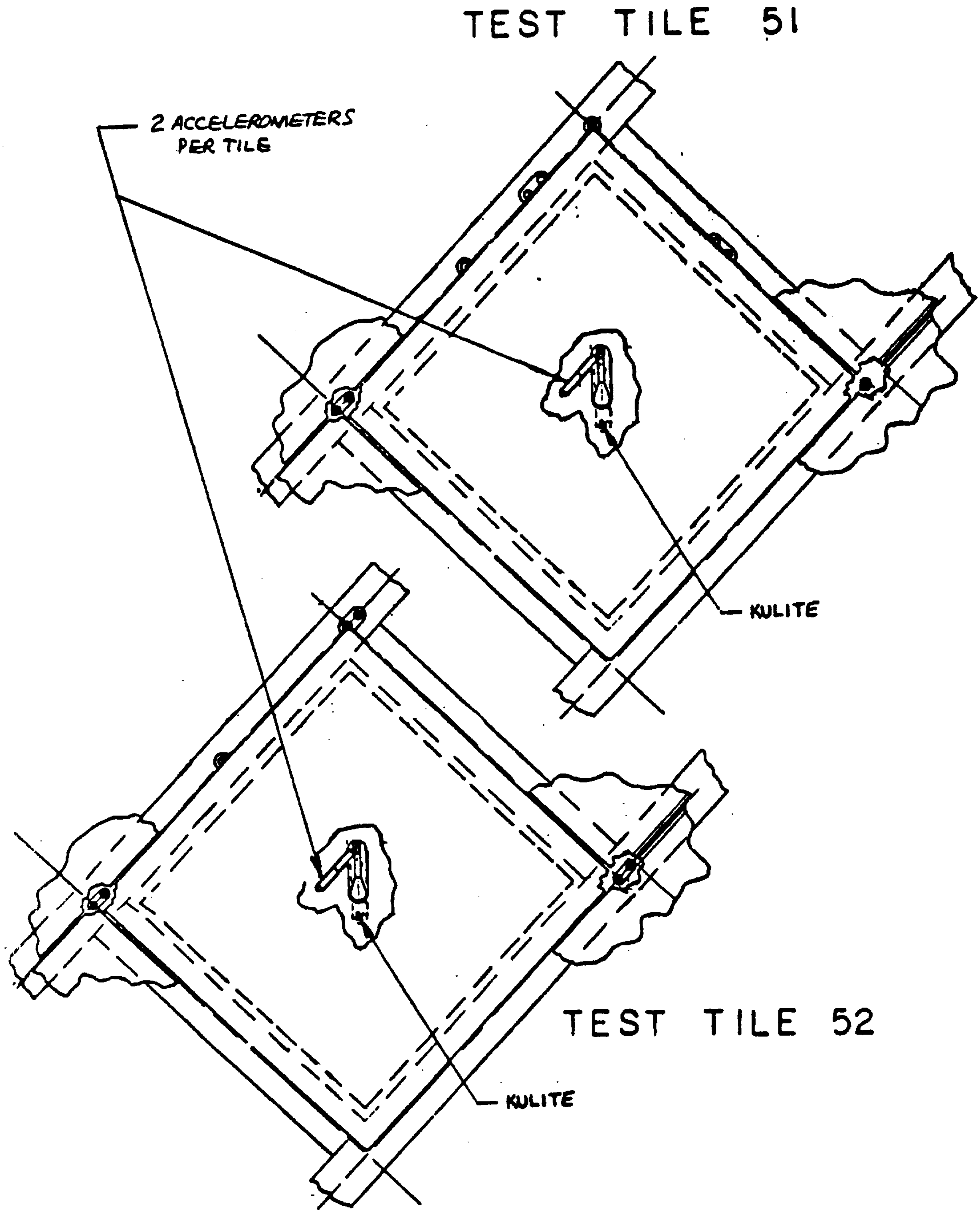


Figure 26, 20A Test Panel Accelerometer Monitor Tiles

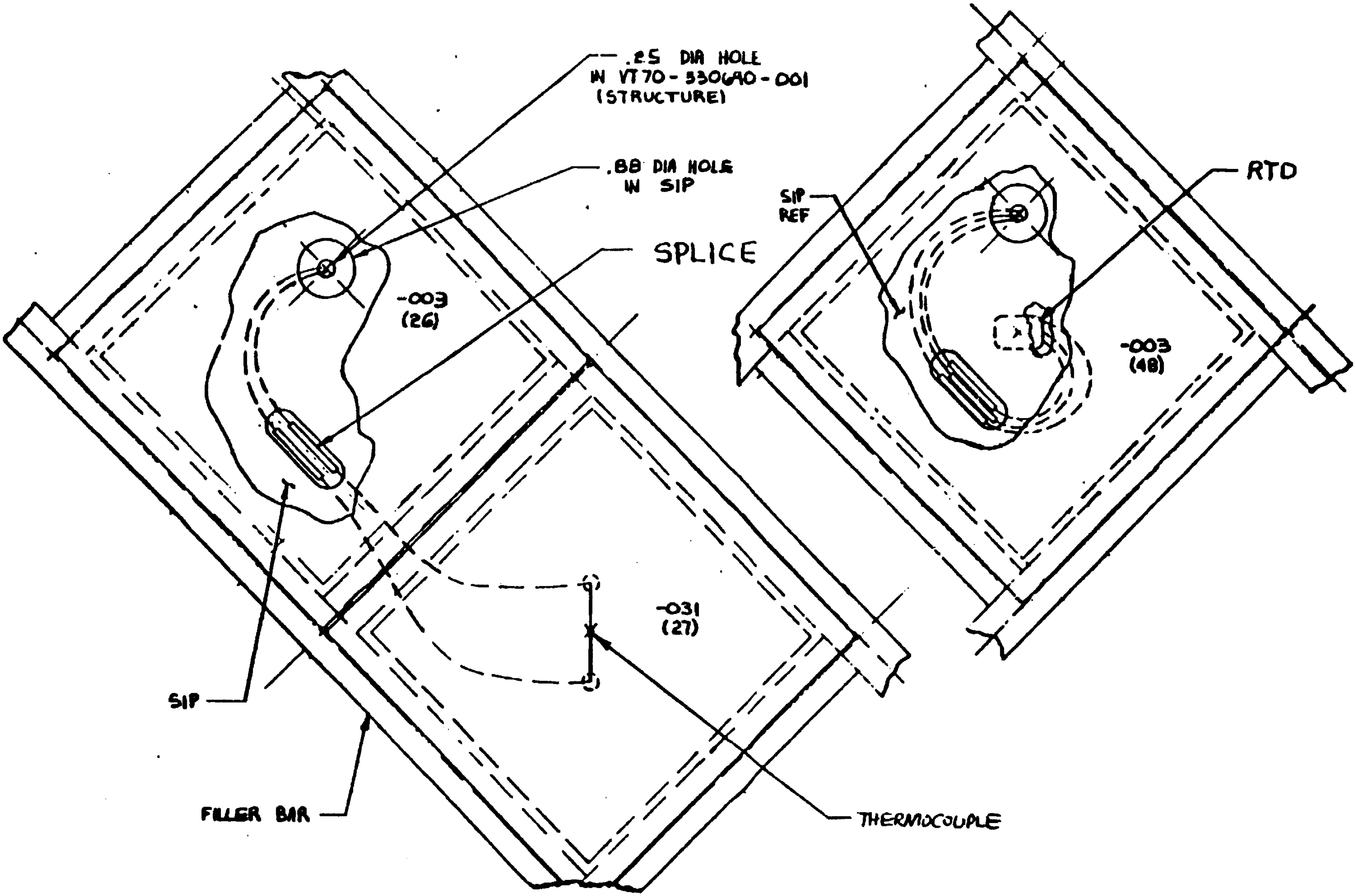
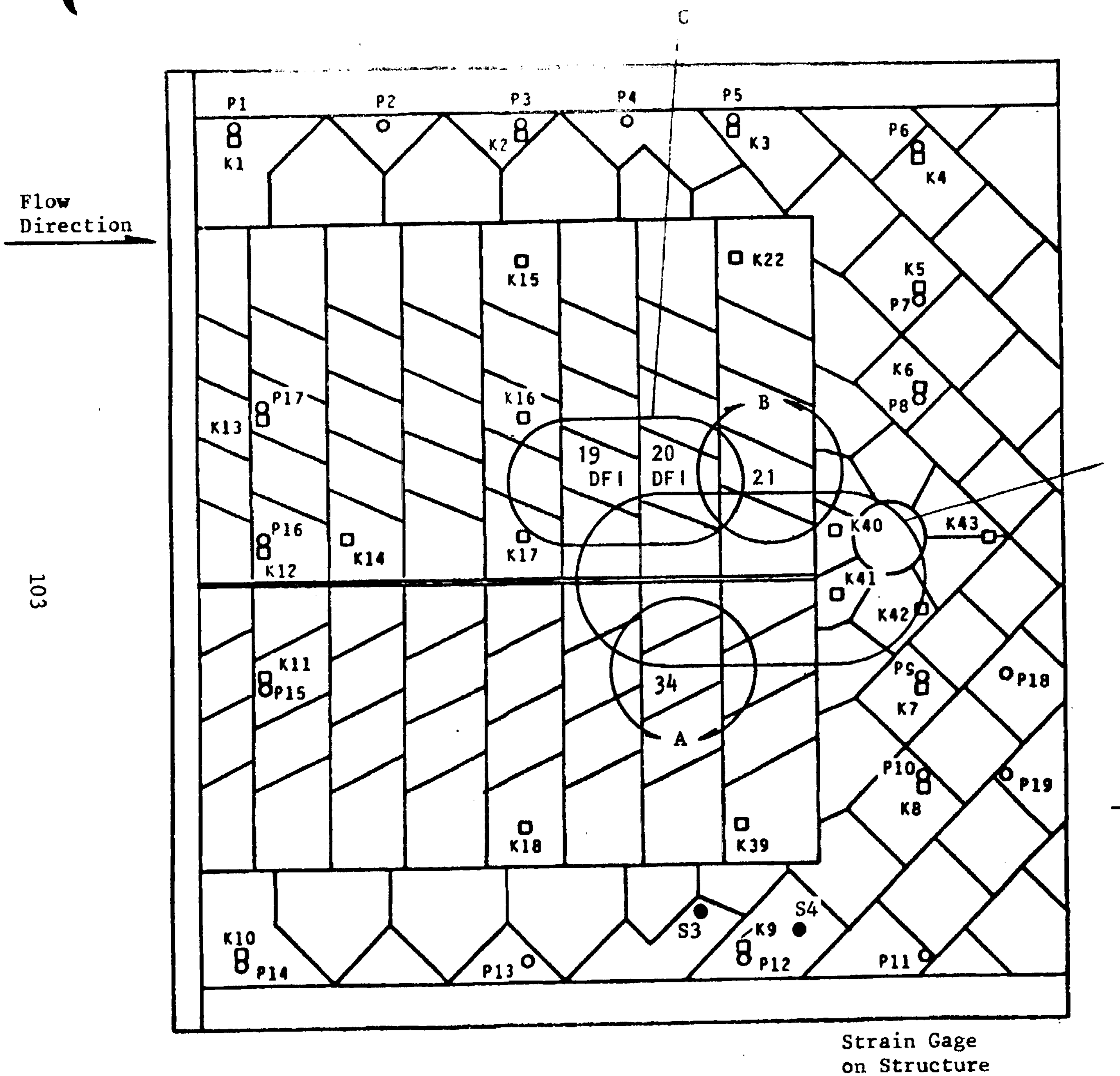


Figure 27. 20A Test Panel DFI Instrumentation



8	Coe Gages
29	Kulites (differential)
11	Kulites (absolute)
63	Pressure Tubes
22	Accelerometers
4	Strain Gages
137	Measurements

Figure 28. 20C Test Panel Instrumentation

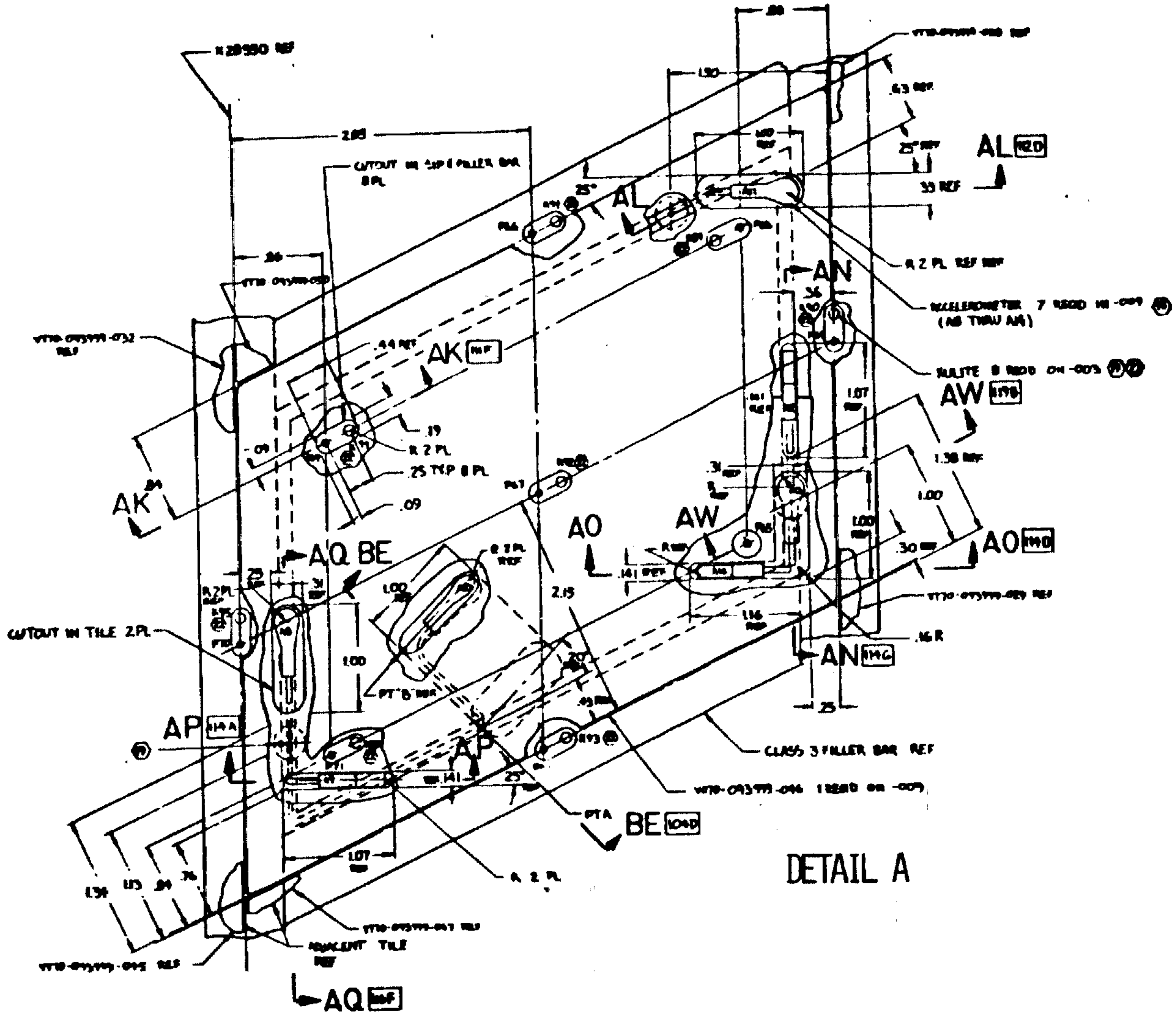


Figure 29. 9 PCF Silica Tile Inst. (Detail A)
Test Panel 20C

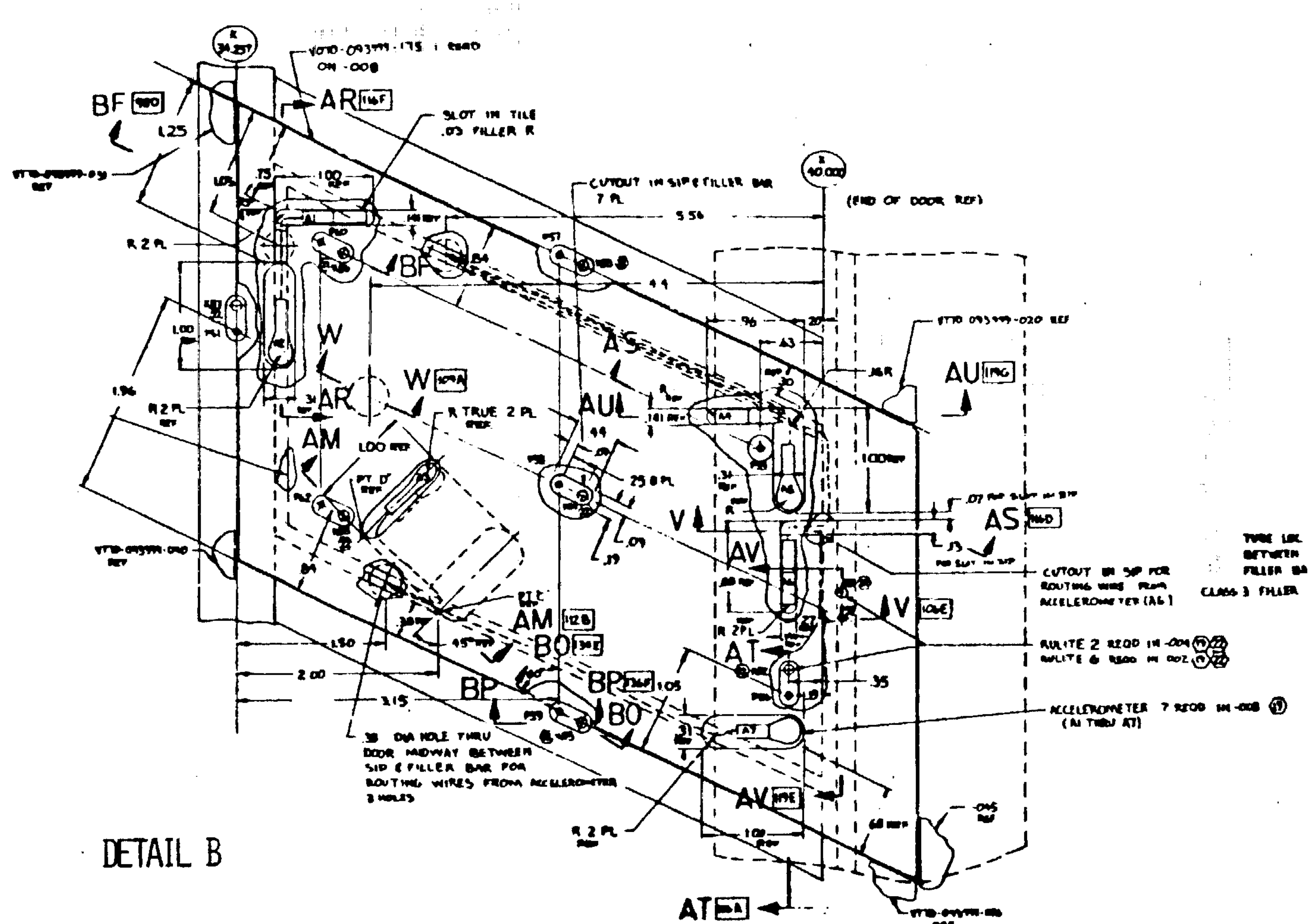


Figure 30. 22 PCF Silica Tile Inst. (Detail B)
Test Panel 20C

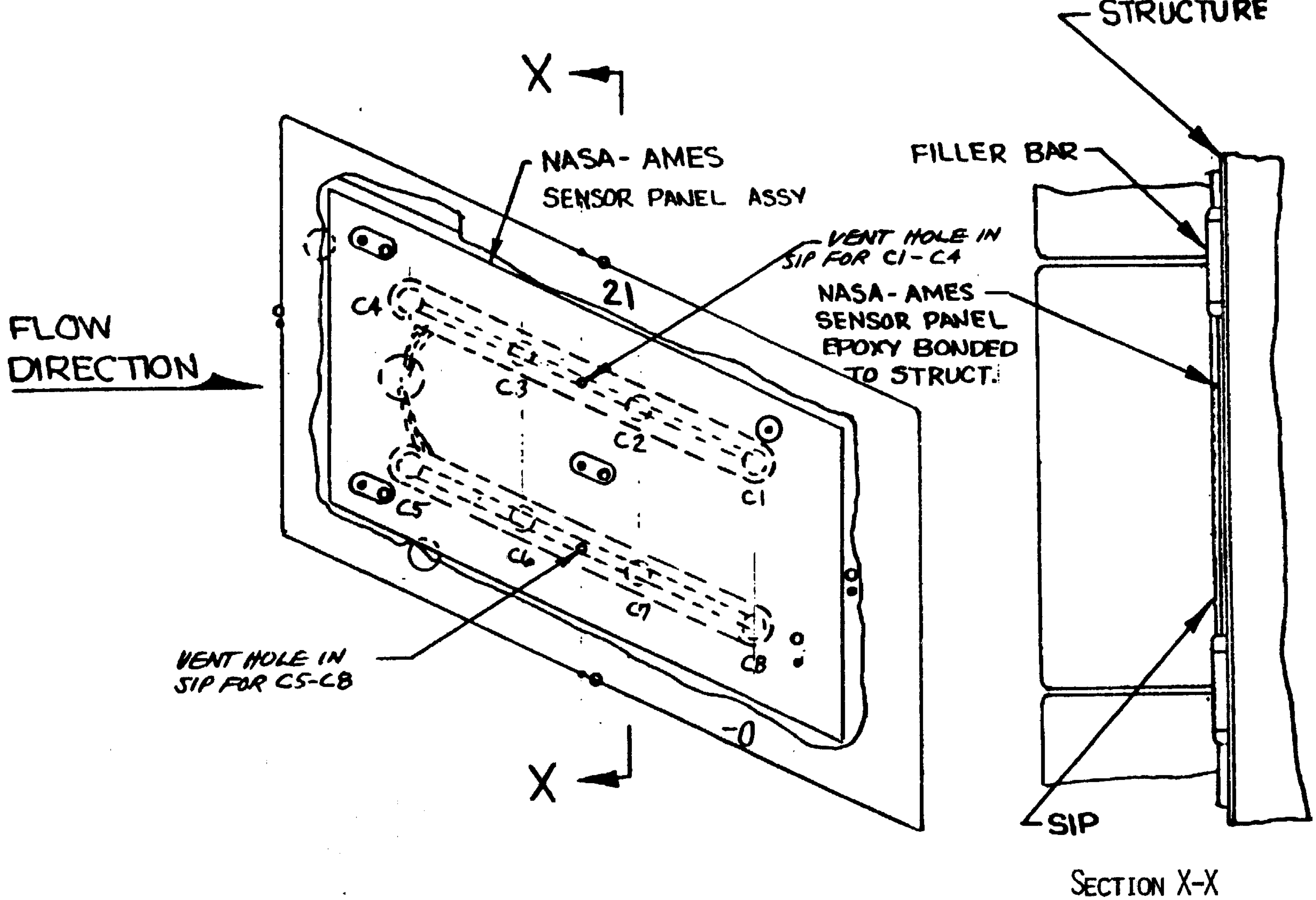
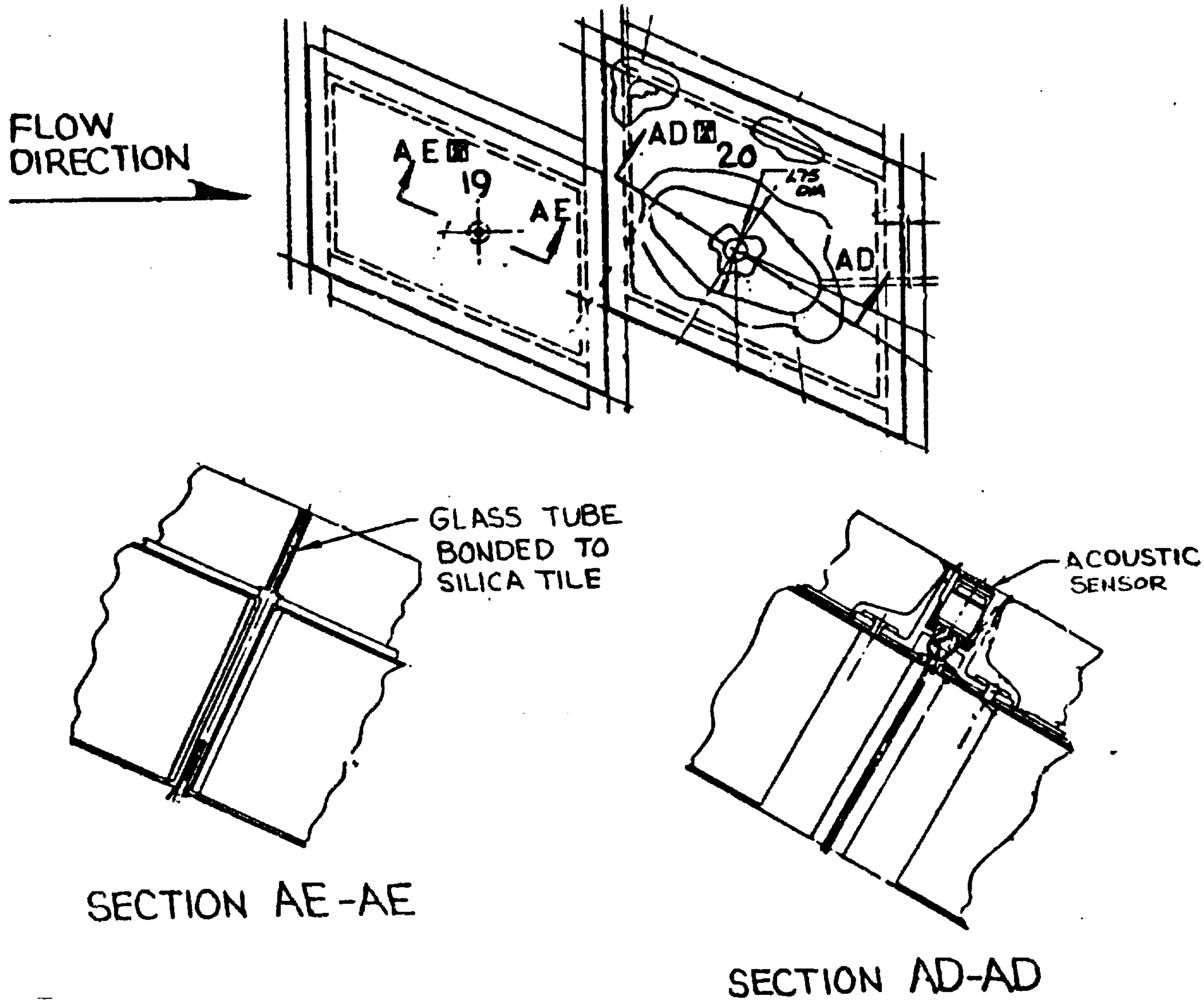
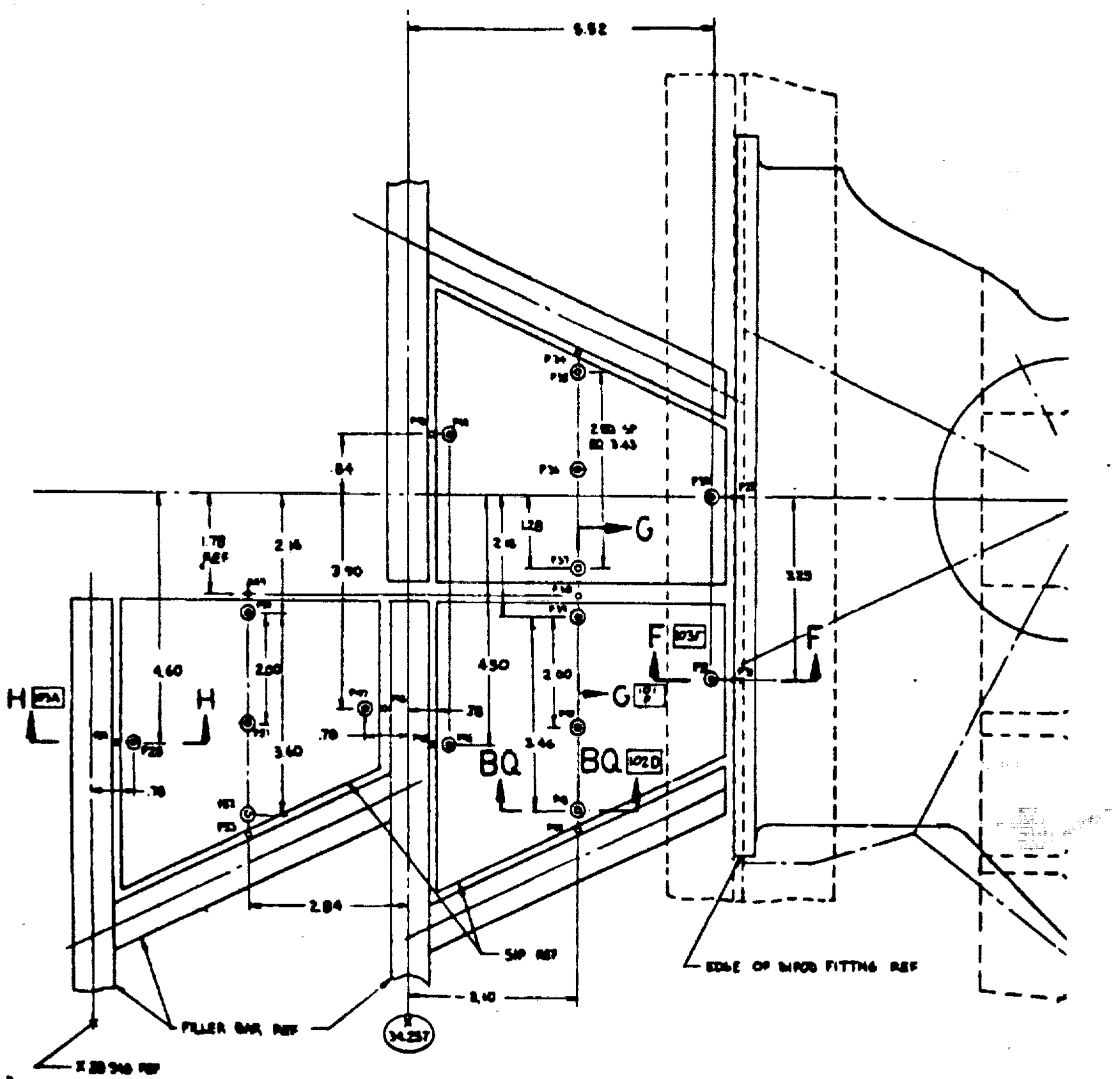


Figure 31. Ames "Coe" Tile Inst. (Tile #21)
Test Panel 20C



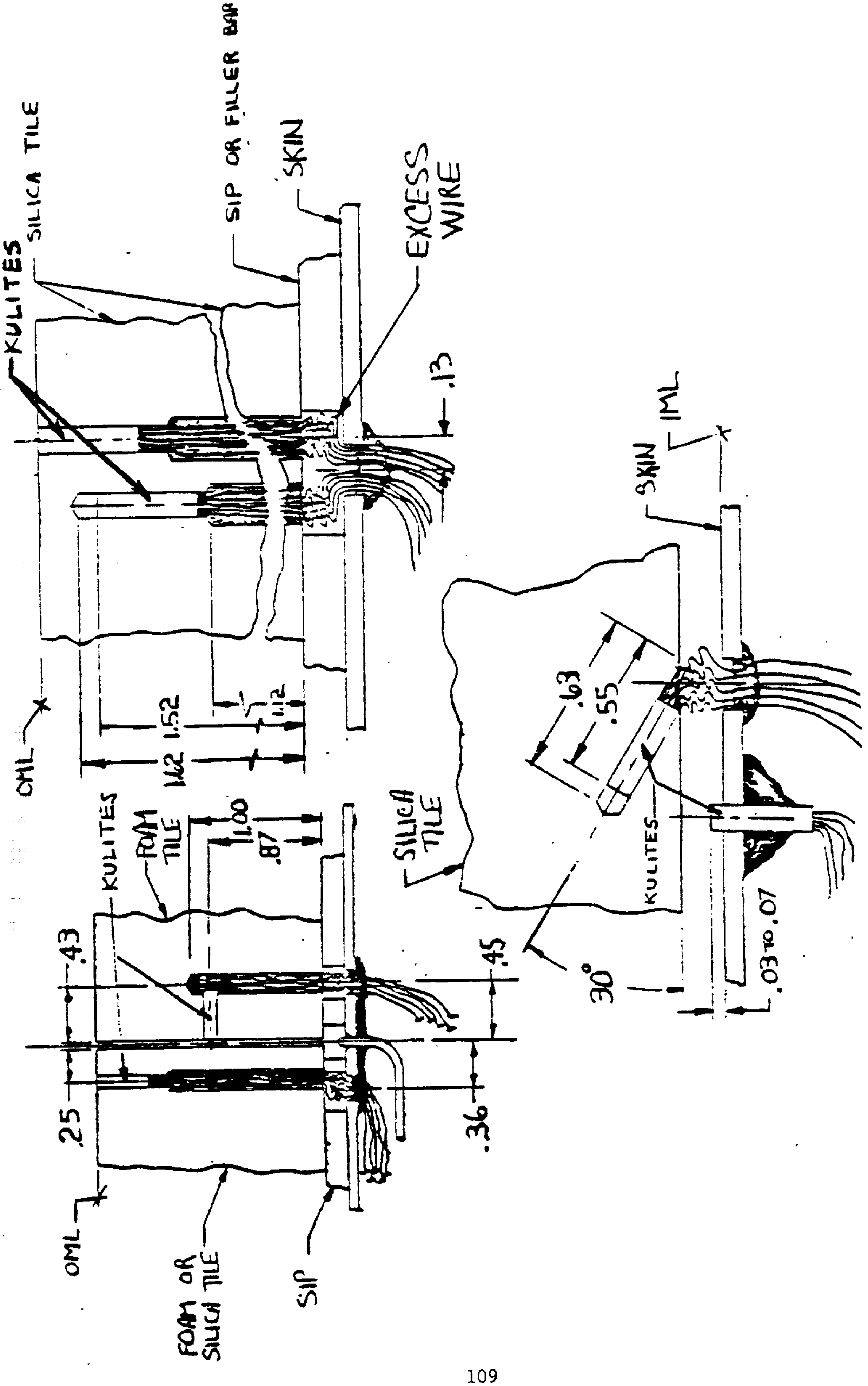
DETAIL C

Figure 32. DFI Instrumentation Test Panel 20C (Detail C)



DETAIL D

Figure 33. 20C Test Panel Instrumentation
(Detail D)


KULITES
SILICA TILE
SIP OR FILLER BAR
SKIN
EXCESS WIRE
.13
OML
1.62
1.52
1.12
IML
SKIN
.63
.55
SILICA TILE
KULITES
30°
.45
.03 TO .07
KULITES
FOAM TILE
1.00
.87
.43
.25
.36
OML
FOAM OR SILICA TILE
SIP

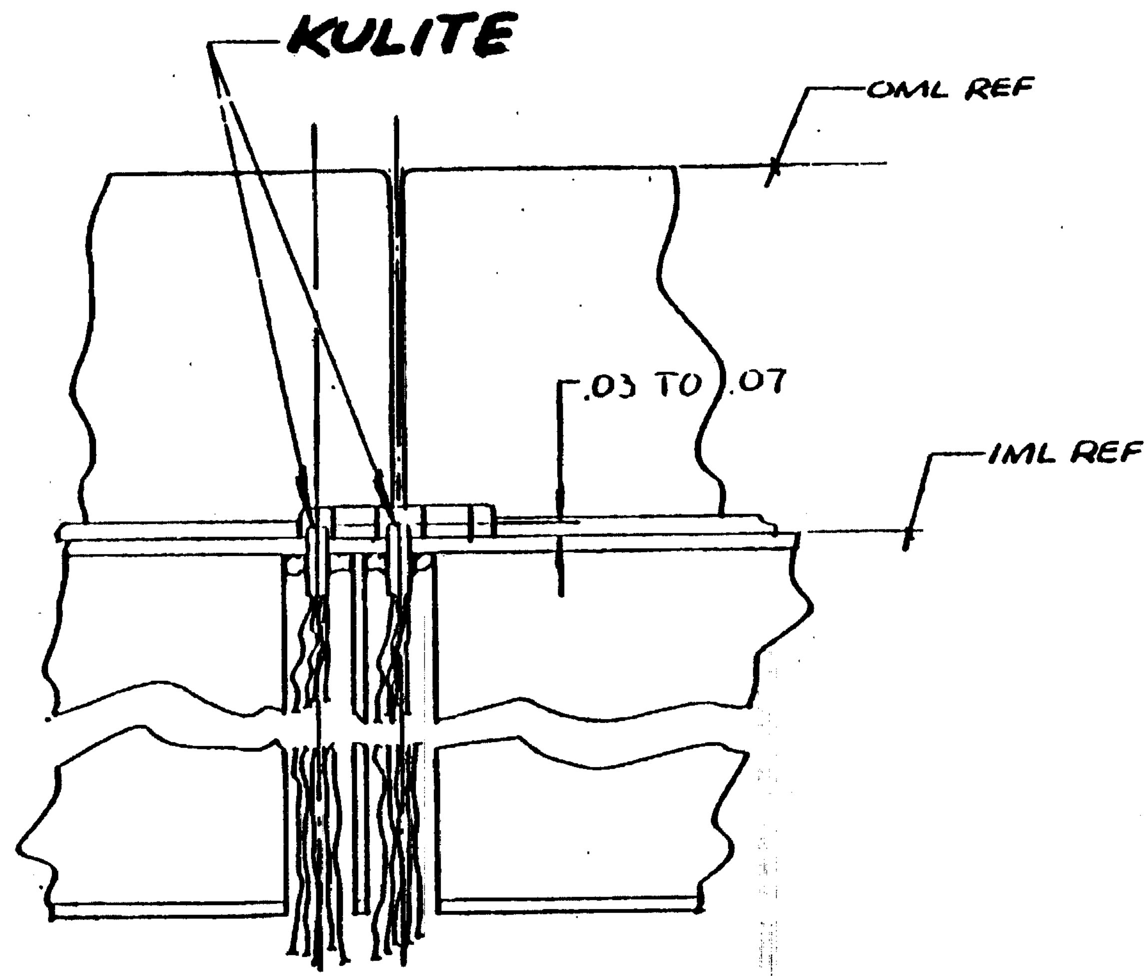


Figure 35. Kulite Installation in Filler Gaps

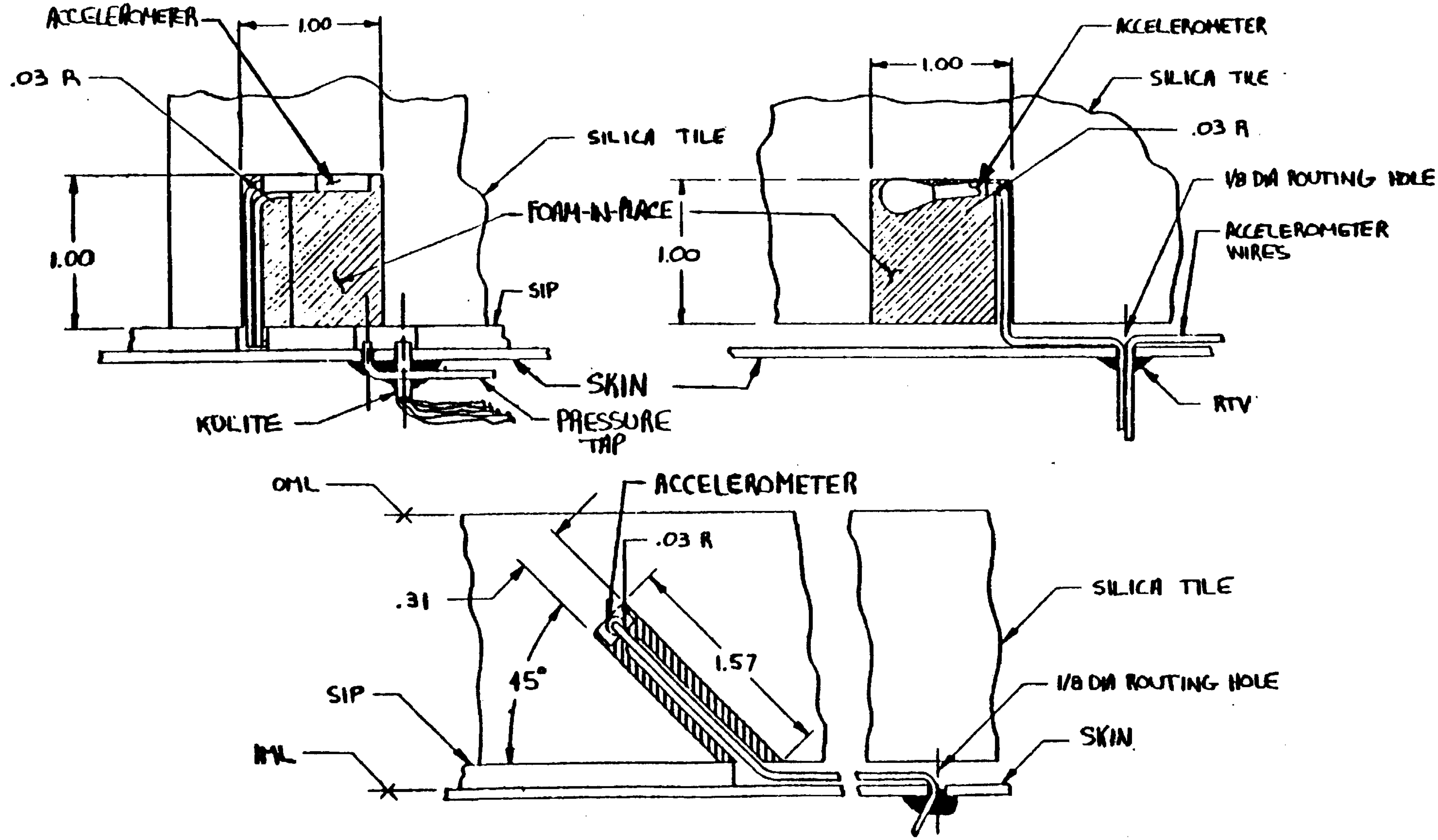


Figure 36. Accelerometer Installation in SIP Mounted Tile

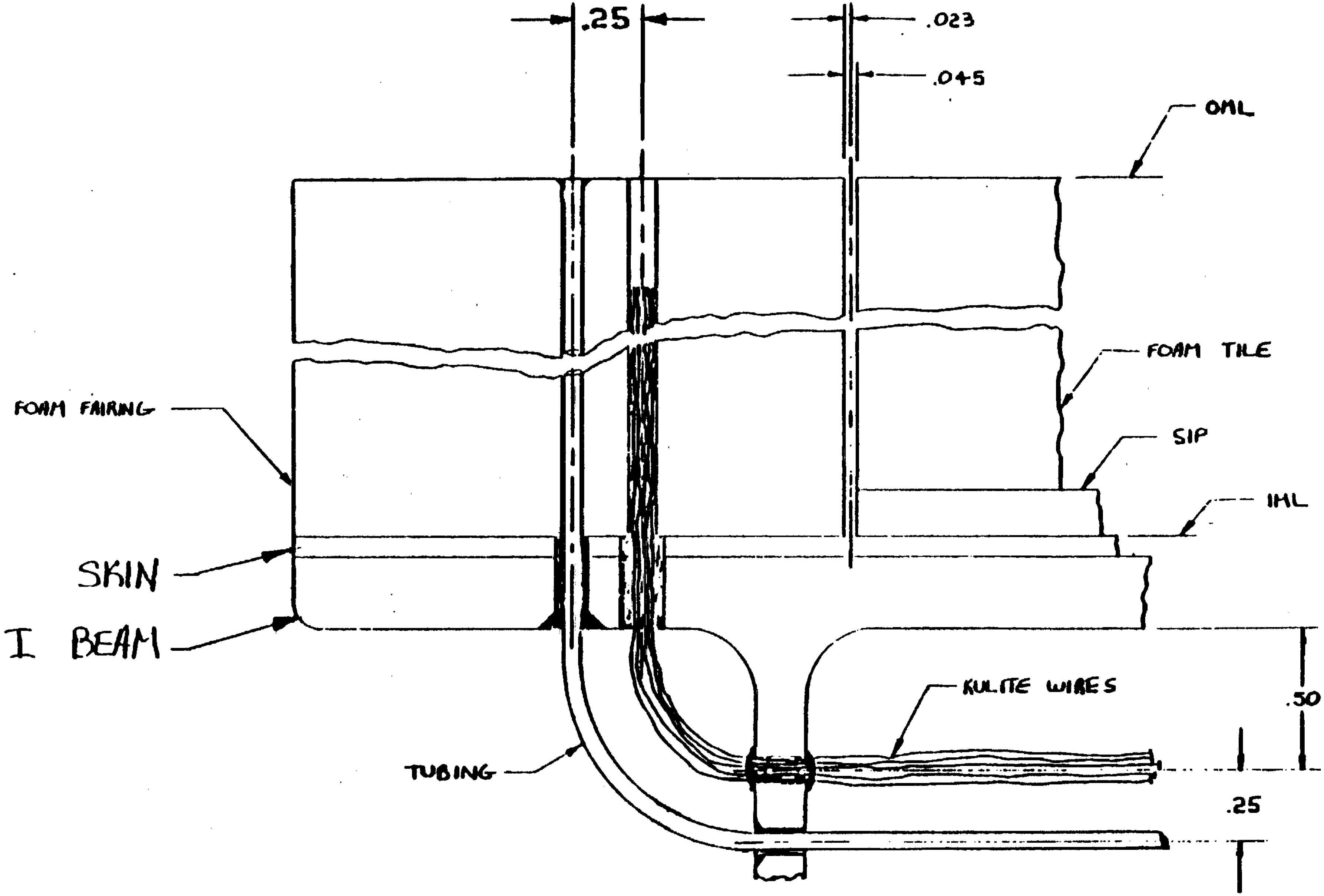


Figure 37. Kulite Pressure Tube Installation
for Direct Bond Foam

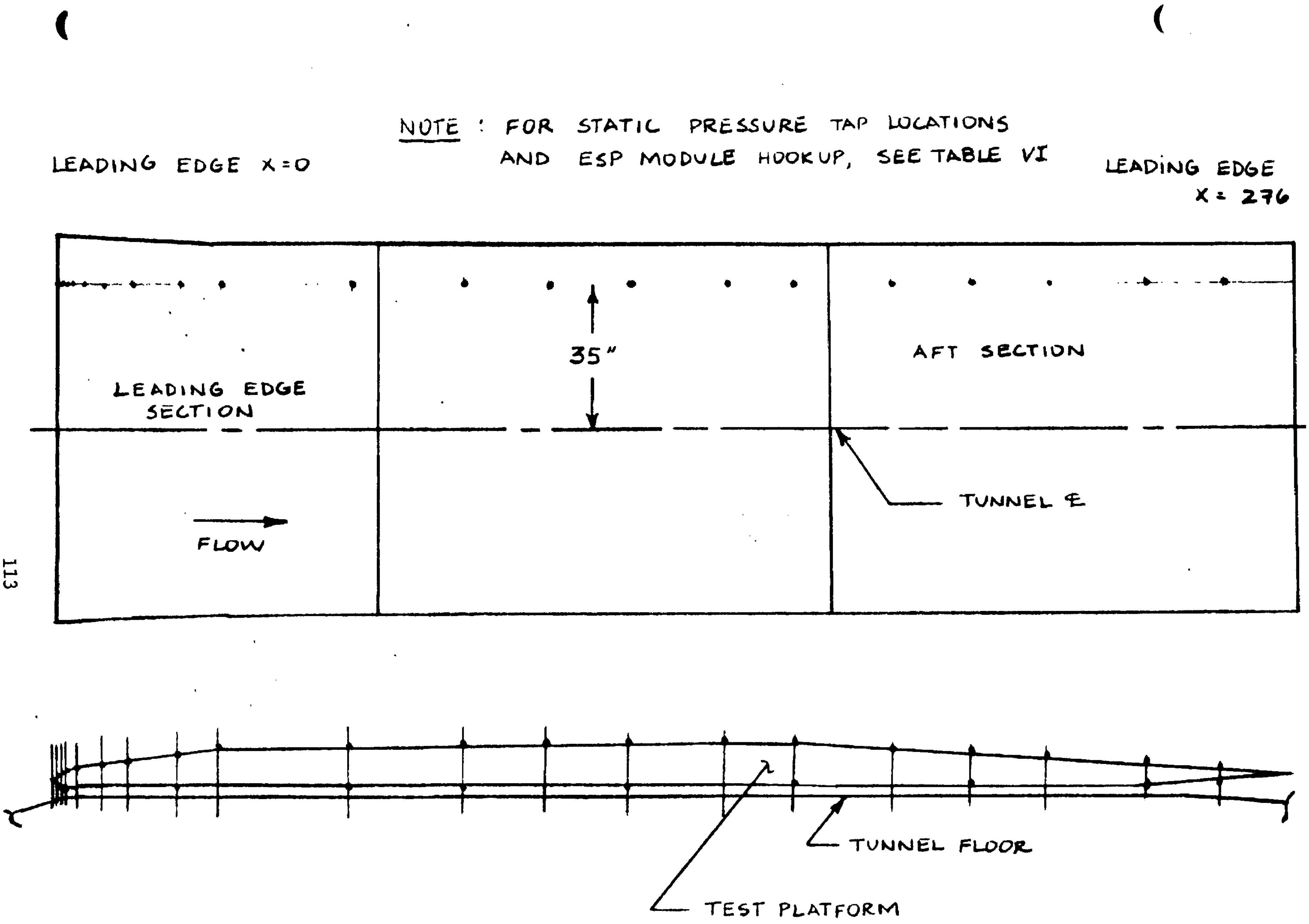


Figure [illegible]. Test Platform Instrumentation

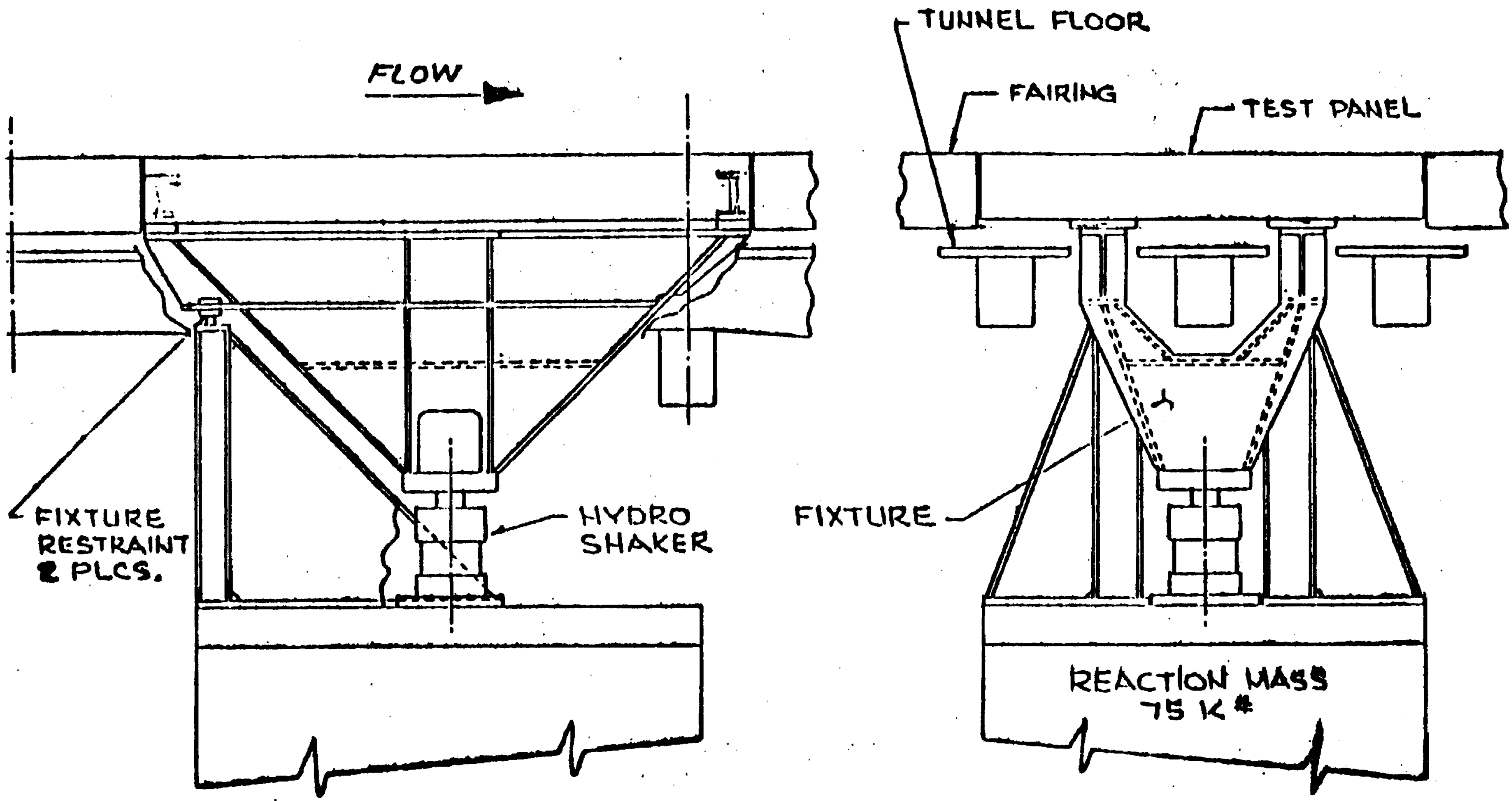


Figure 39. Shaker Installation in the LRC 8' TPT

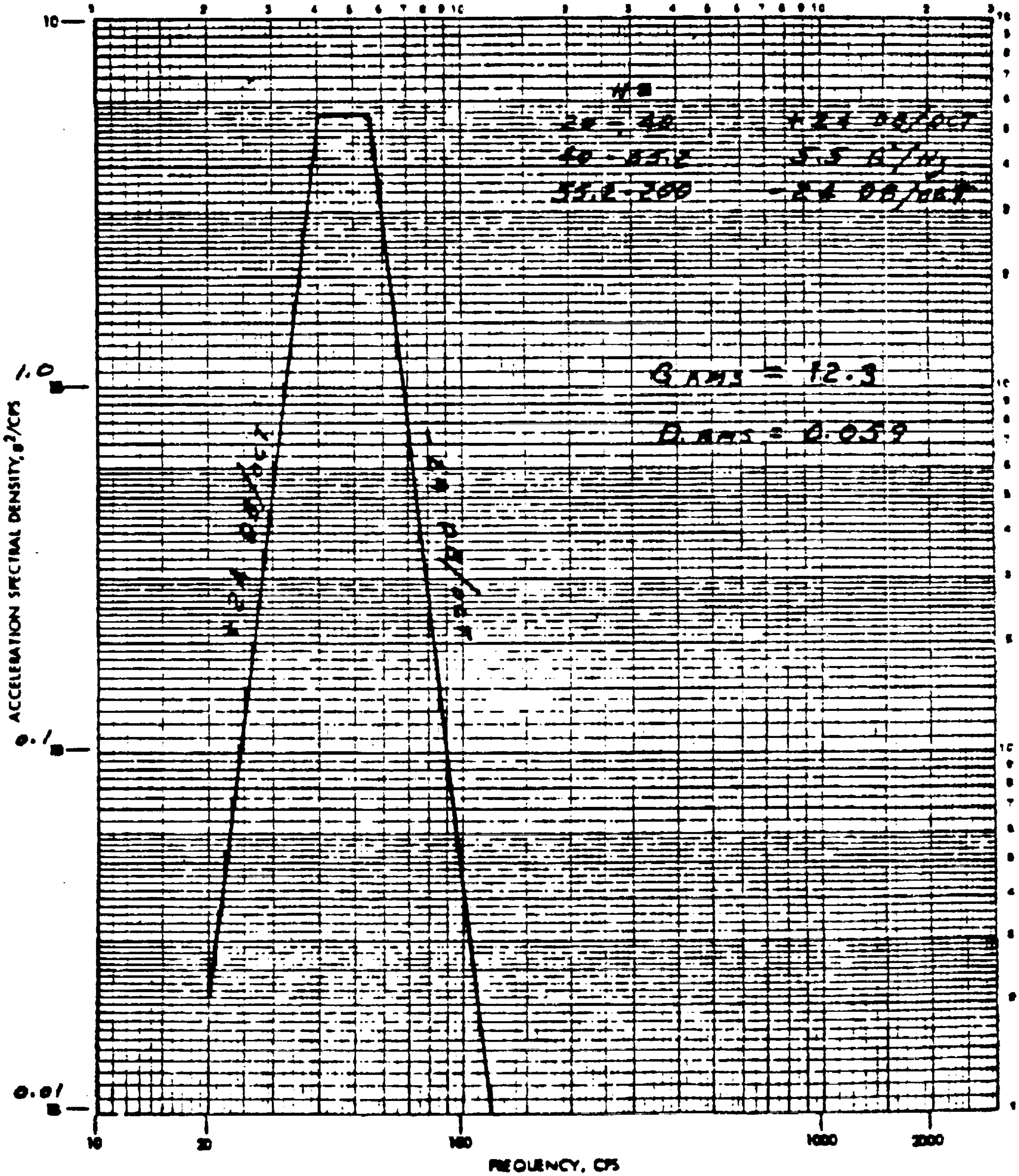


Figure 40. Shaker Frequency Spectrum
CLOT Test OS-53A

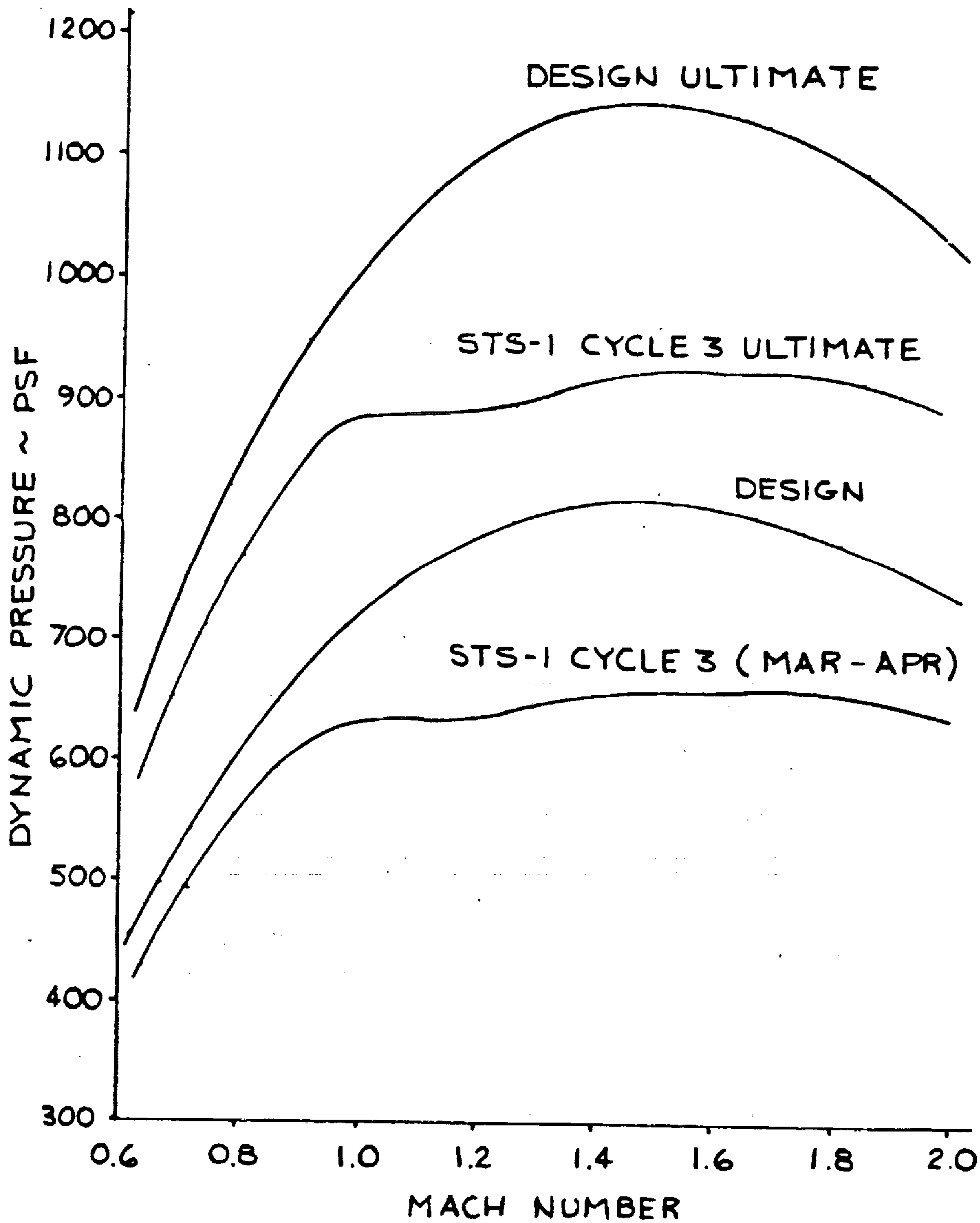
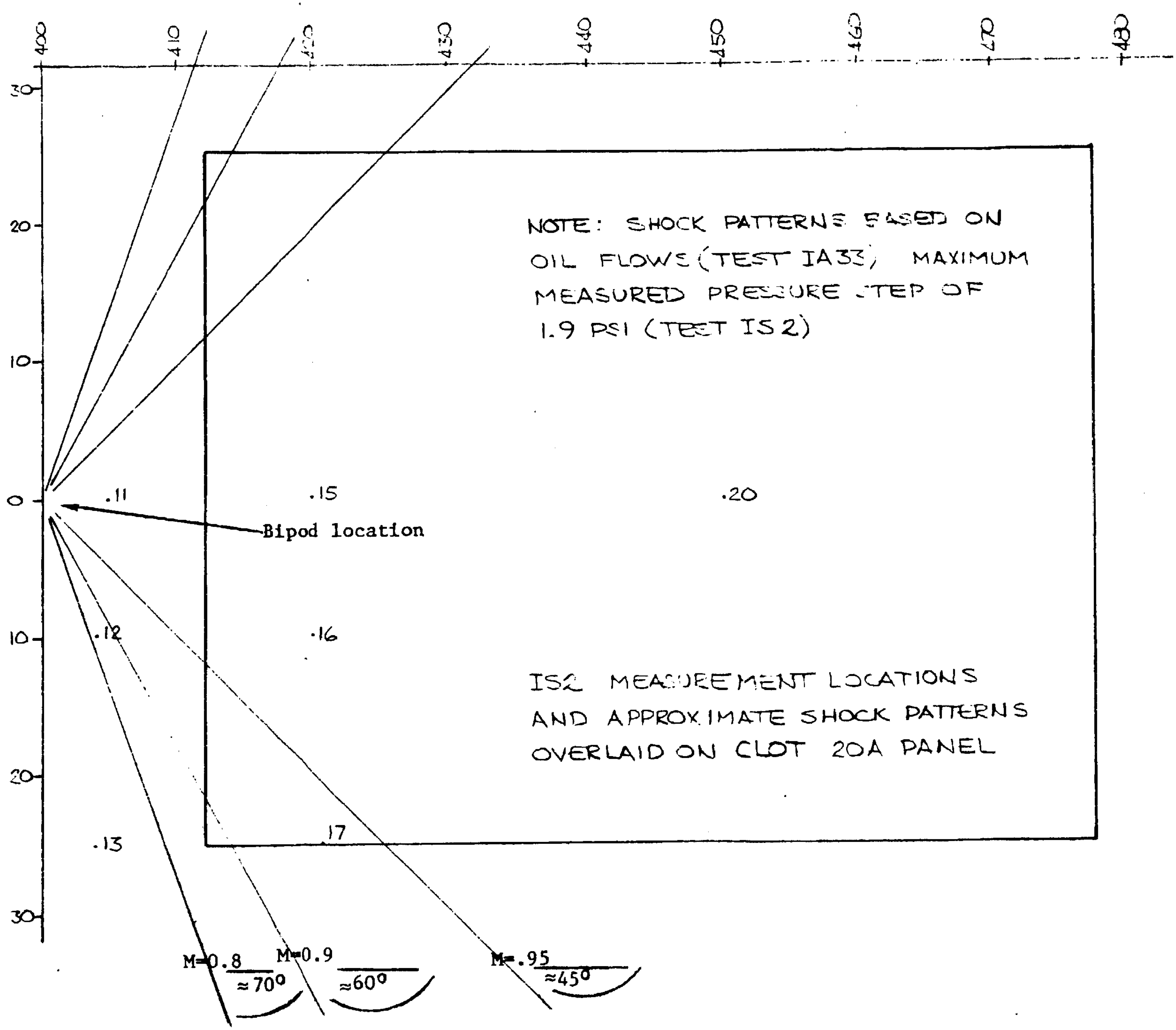


FIGURE 41. ORBITER BOOST TRAJECTORY



NOTE: SHOCK PATTERNS BASED ON OIL FLOWS (TEST IA33) MAXIMUM MEASURED PRESSURE STEP OF 1.9 PSI (TEST IS2)
IS2 MEASUREMENT LOCATIONS AND APPROXIMATE SHOCK PATTERNS OVERLAID ON CLOT 20A PANEL
Bipod location
.11
.12
.13
.15
.16
.17
.20
M=0.8
≈70°
M=0.9
≈60°
M=.95
≈45°
400
410
420
430
440
450
460
470
480
30
20
10
0
10
20
30

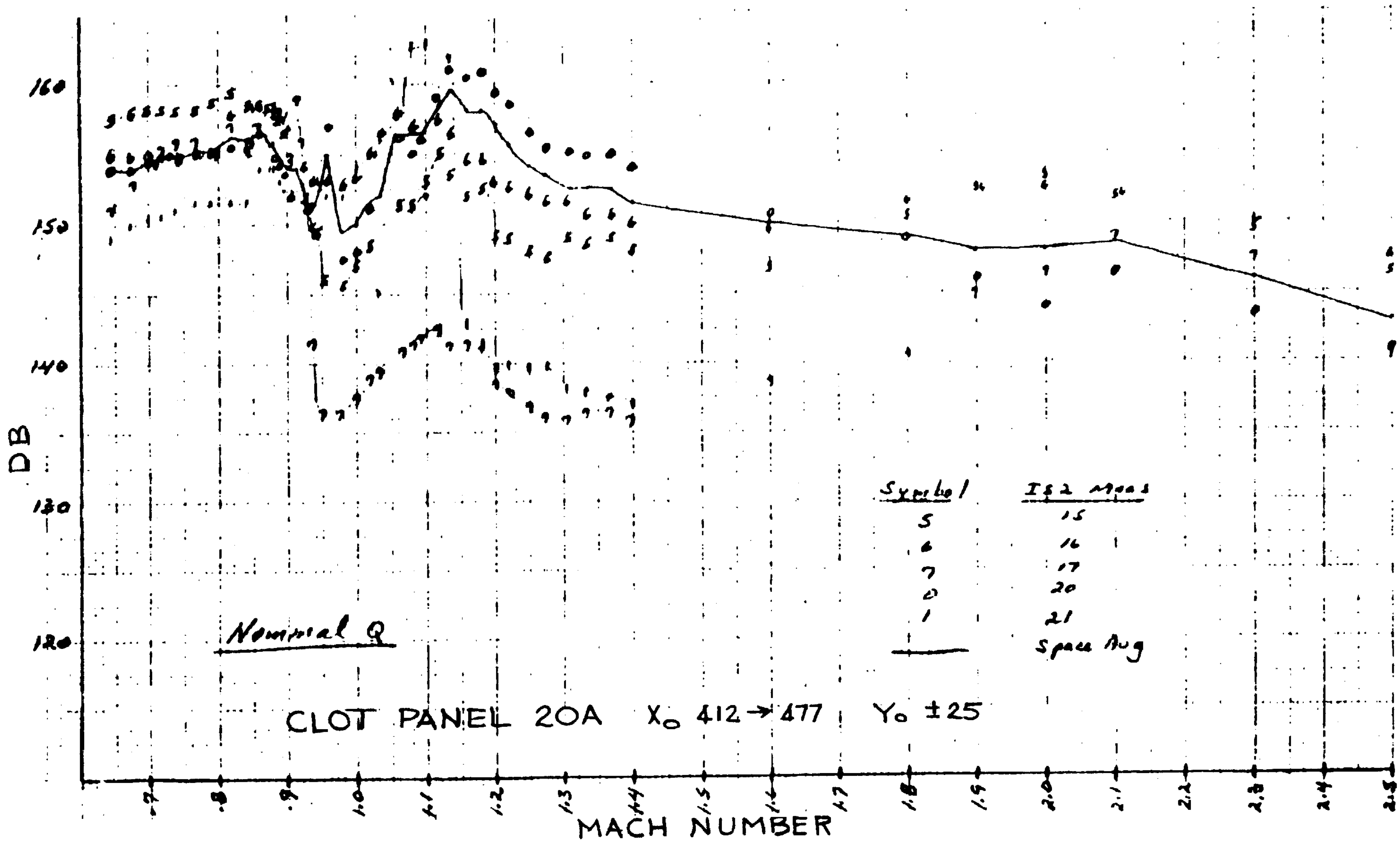
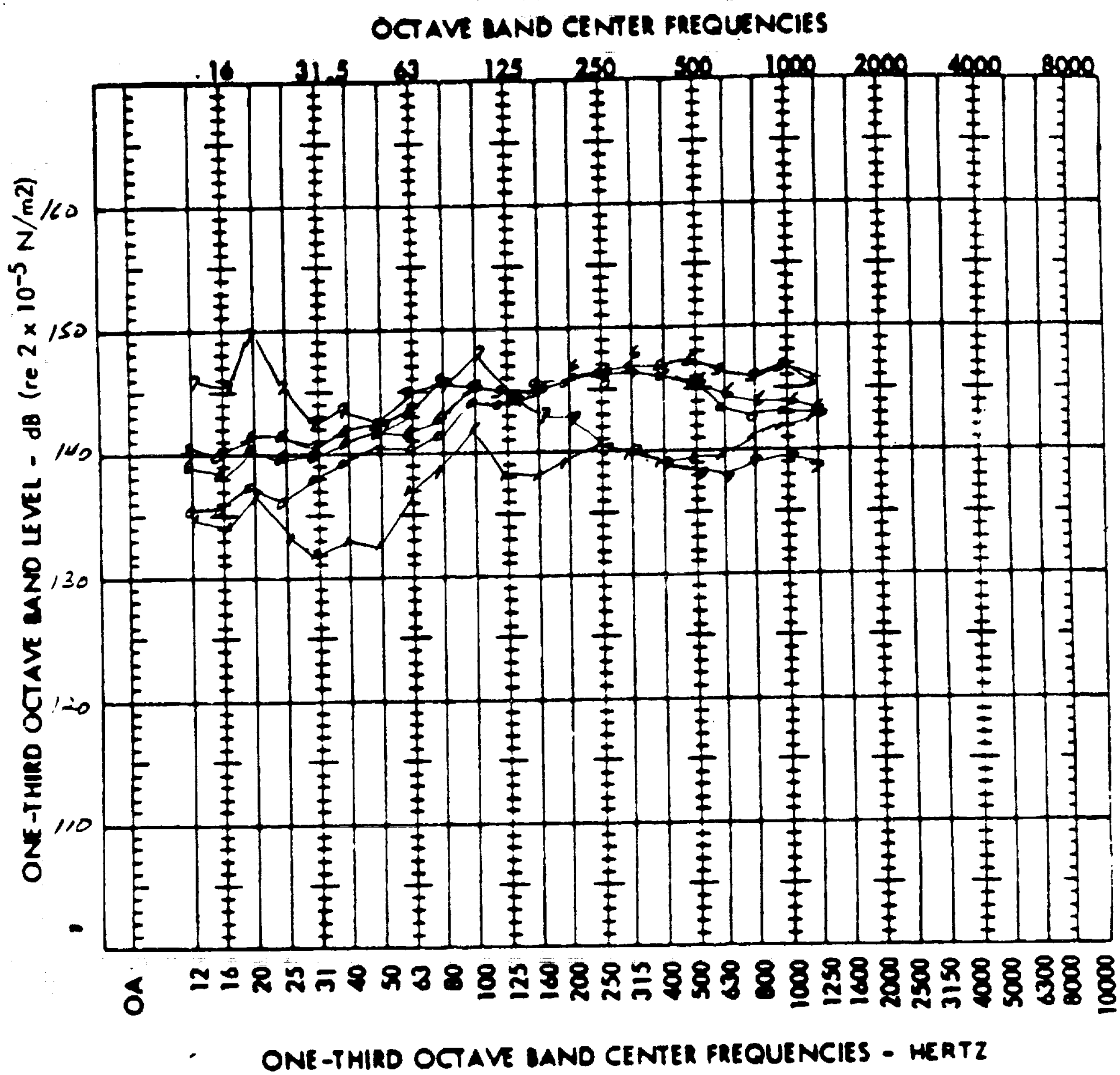


FIGURE 43 - ORBITER LOCAL FLOW CONDITIONS - (BOUNDARY LAYER NOISE)

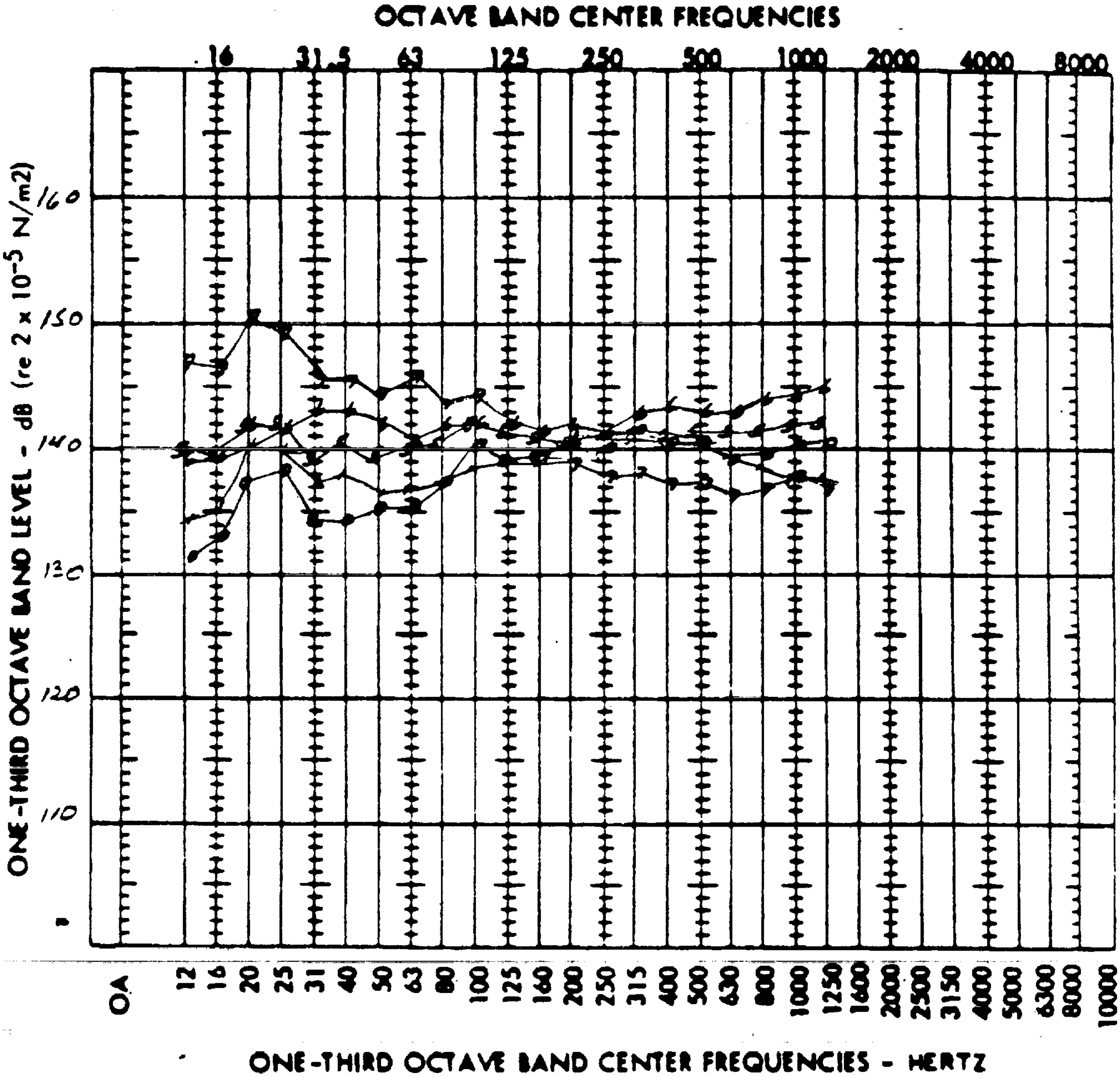


IS2 MACH .864 α/β = 0/0

CLOT 20 # Panel

Sym	Meas
5	15
6	16
7	17
0	20
1	21

FIGURE 44 - ORBITER LOCAL FLOW CONDITIONS

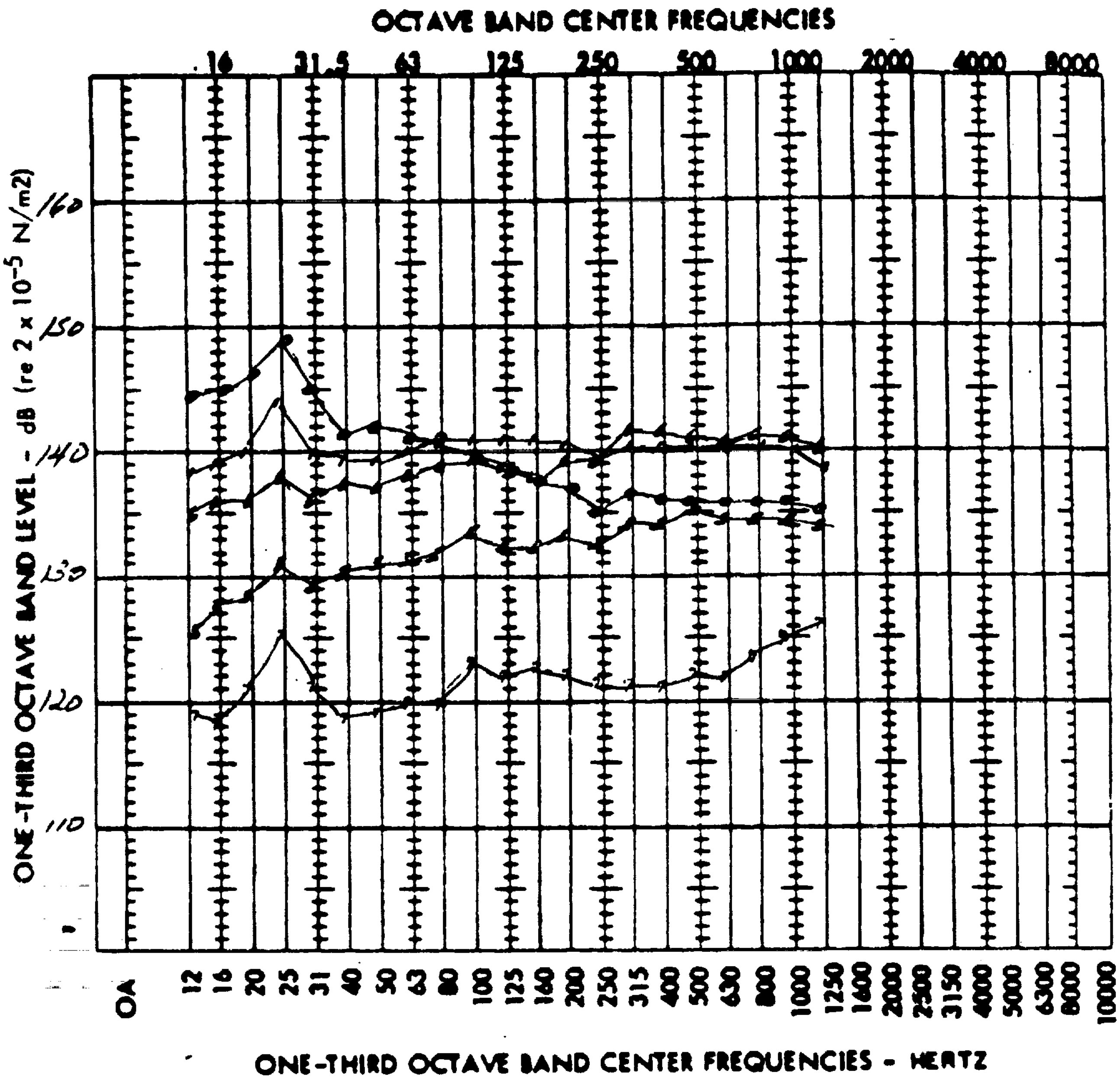


IS2 MACH 0.913 α/s = 0/0

Clot 20B Panel

Sym	Meas
5	15
6	16
7	17
0	20
1	21

FIGURE 45 - ORBITER LOCAL FLOW CONDITIONS

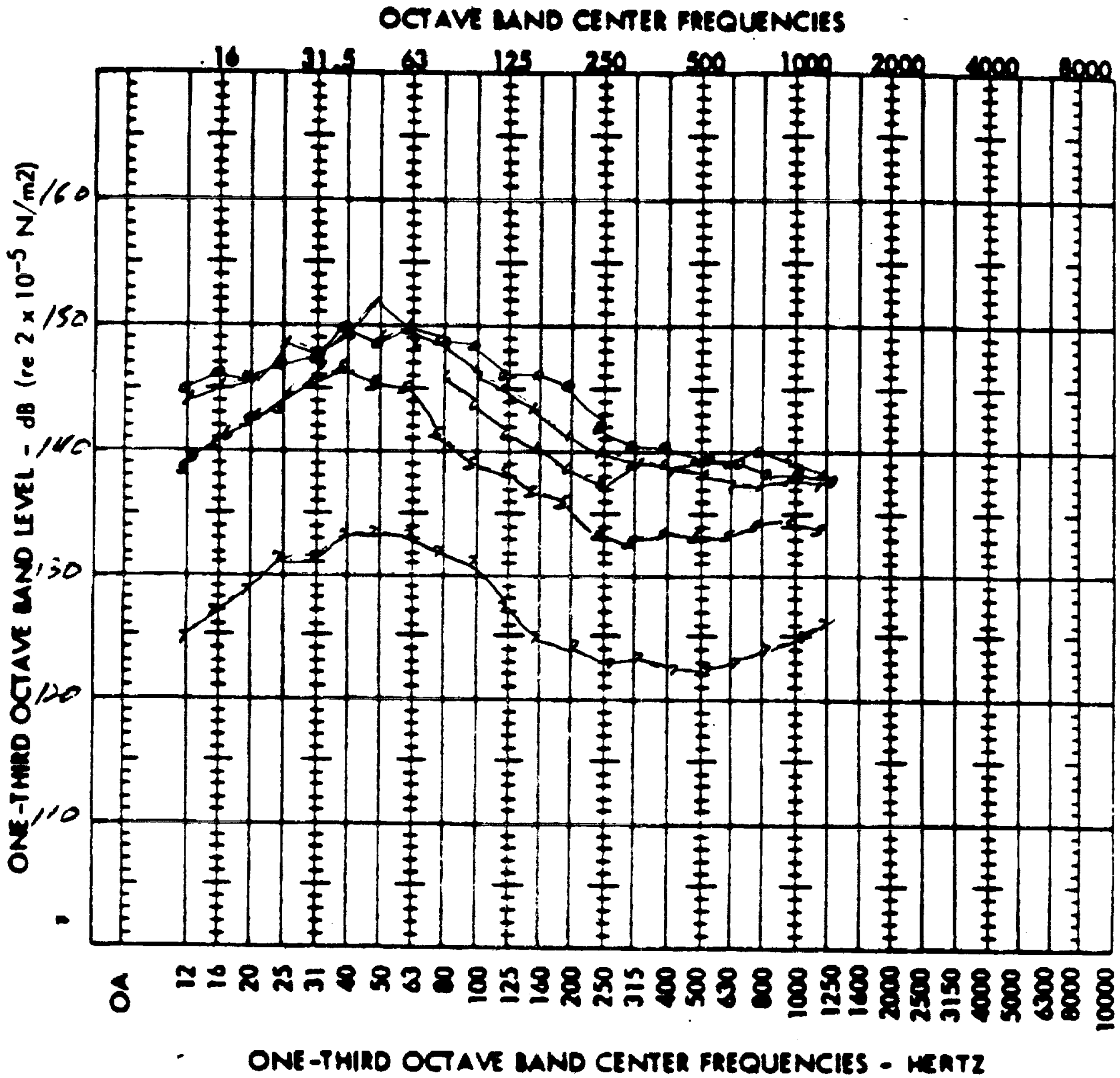


IS2 Mach 0.956 α/β = 0/0

Clot 20A Panel

Sym.	Meas.
5	15
6	16
7	17
0	20
1	21

FIGURE 46 - ORBITER LOCAL FLOW CONDITIONS

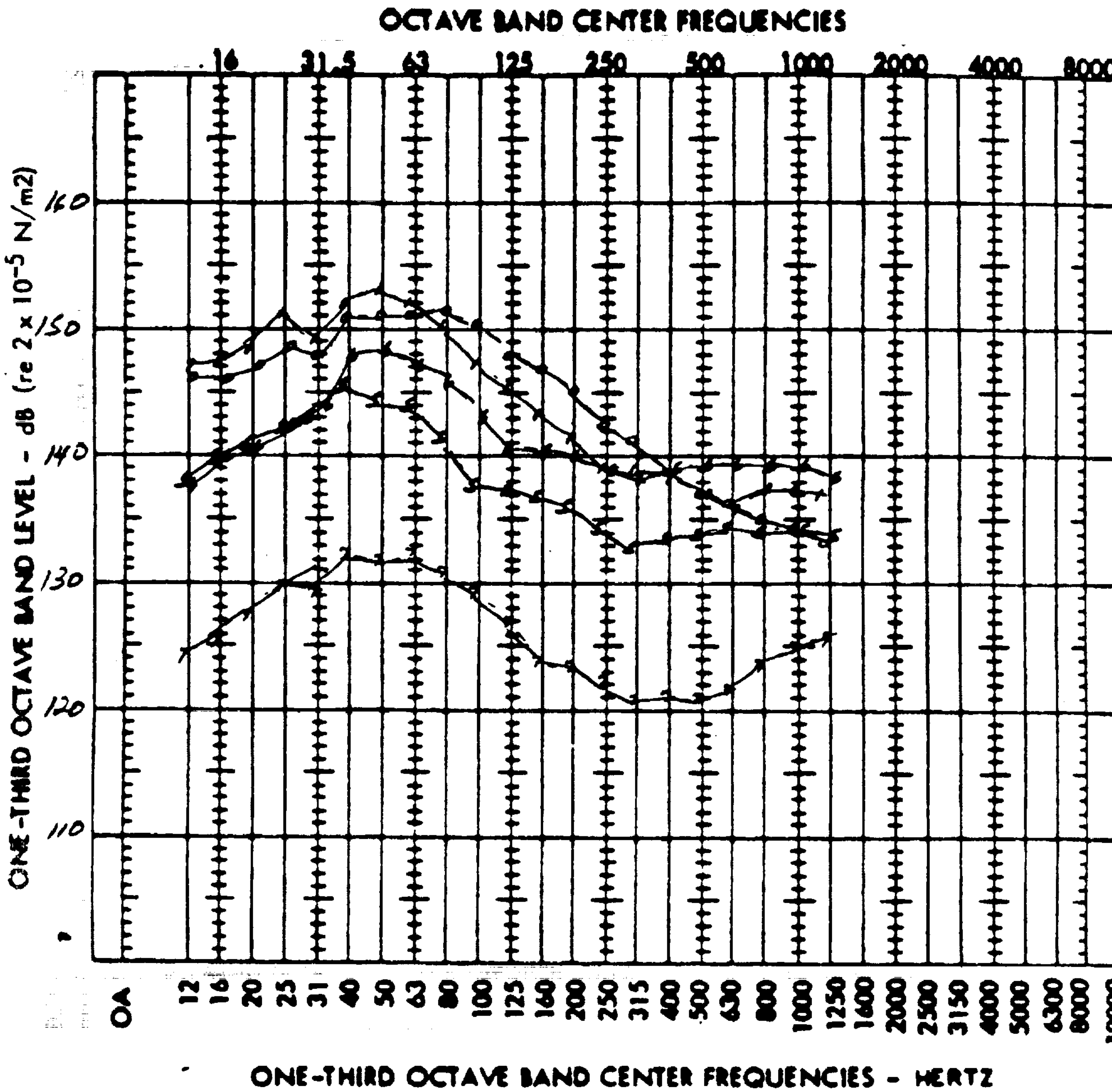


IS2 Mach 1.12 α/β = 0/0

Clot 20A Panel

Sym	Mic
5	15
6	16
7	17
•	20
/	21

FIGURE 47 - ORBITER LOCAL FLOW CONDITIONS

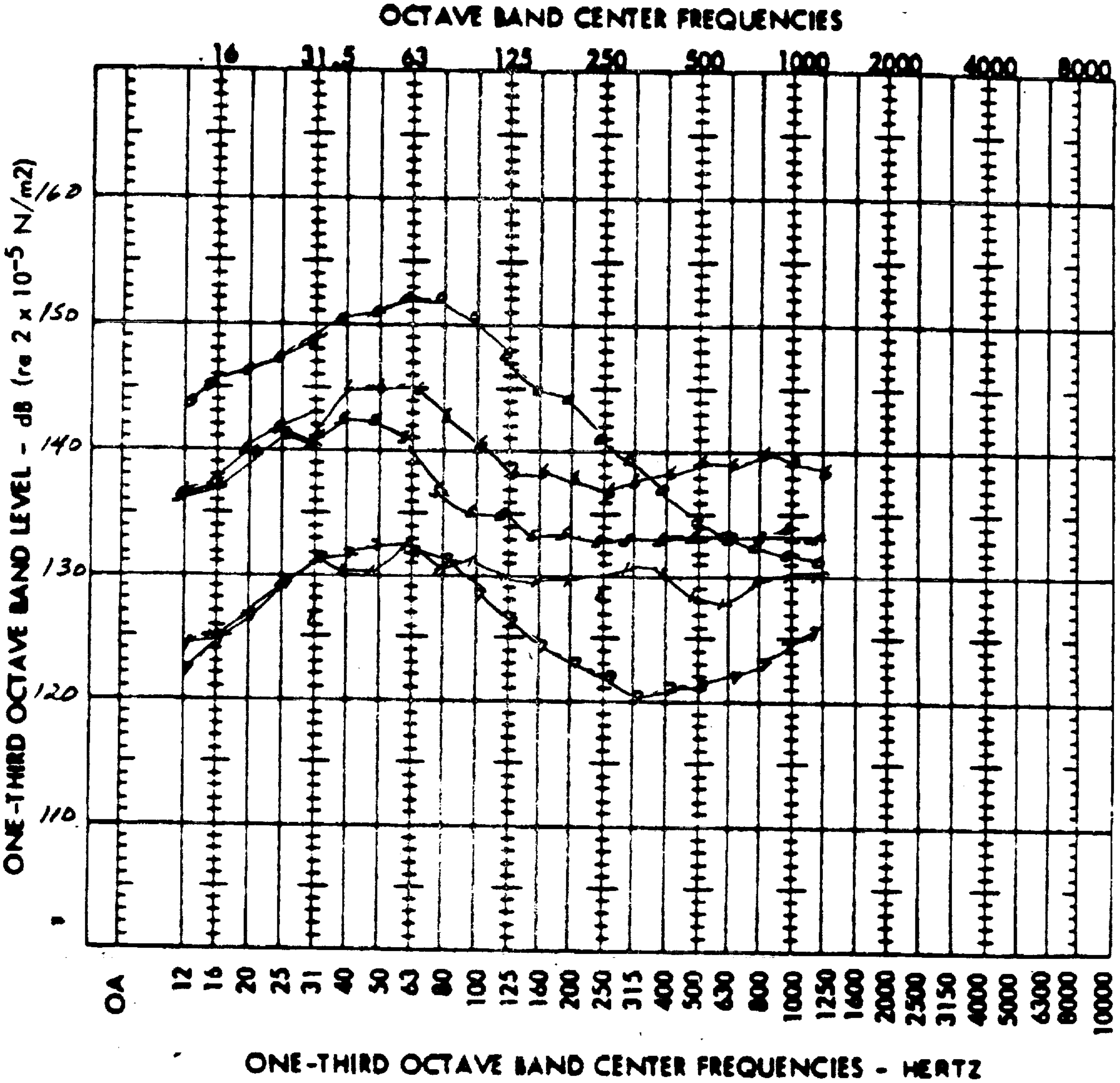


IS2 Mach 1.135 α/β = 0/0

Plot on A Panel

Sym	DMeas
5	15
6	16
7	17
0	20
1	21

FIGURE 48 - ORBITER LOCAL FLOW CONDITIONS

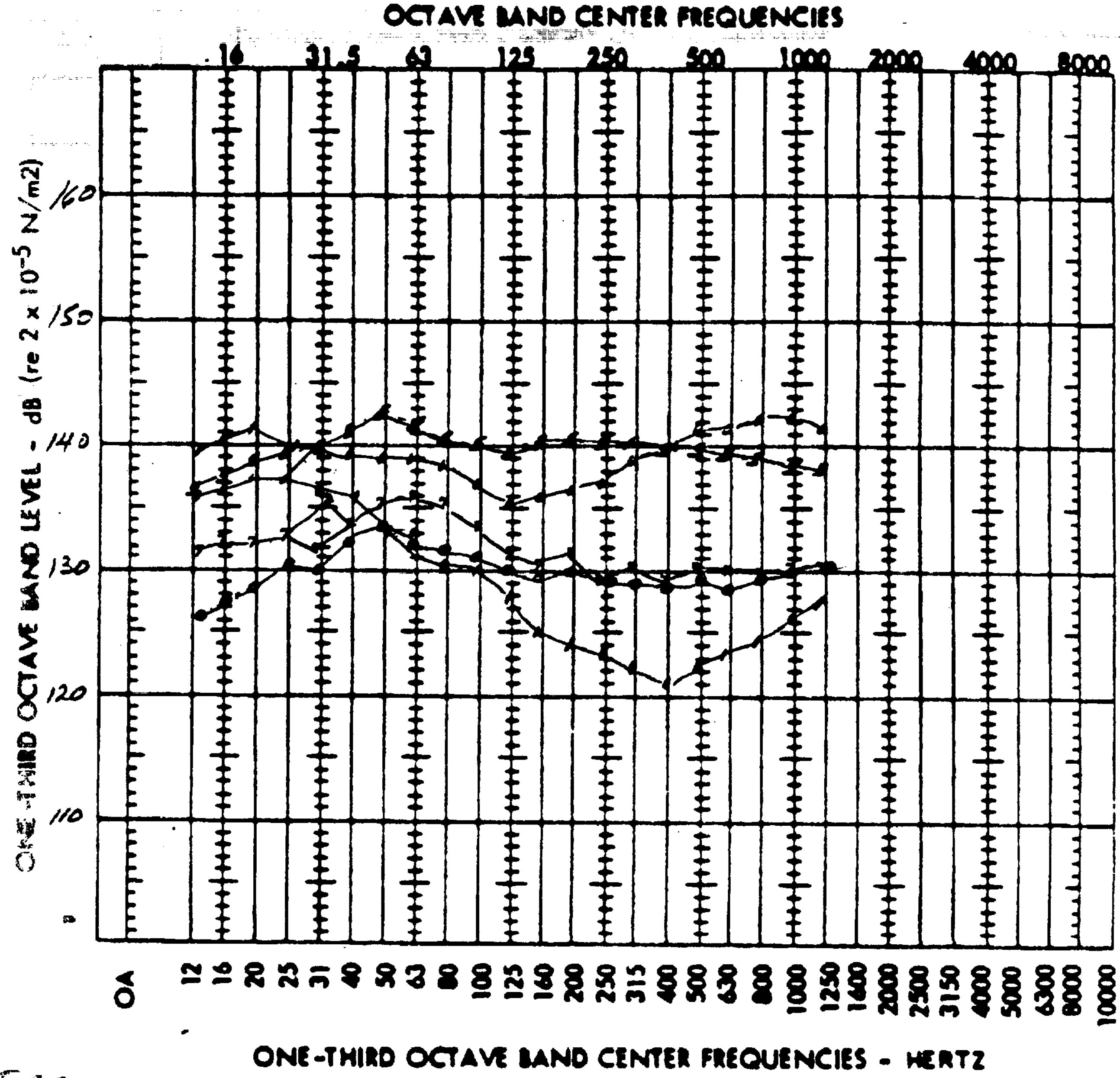


IS2 Mach 1.159 $\alpha/\beta = 0/0$

Cl of 20A Panel

Sym	Meas
5	15
6	16
7	17
0	20
1	21

FIGURE 49 - ORBITER LOCAL FLOW CONDITIONS



IS2

Mach 2.0 $\alpha/\beta = 0.2/-0.1$

CLOT 20 A Panel

Sym	Meas
5	15
6	16
7	17
0	20
1	21

FIGURE 50 - ORBITER LOCAL FLOW CONDITIONS

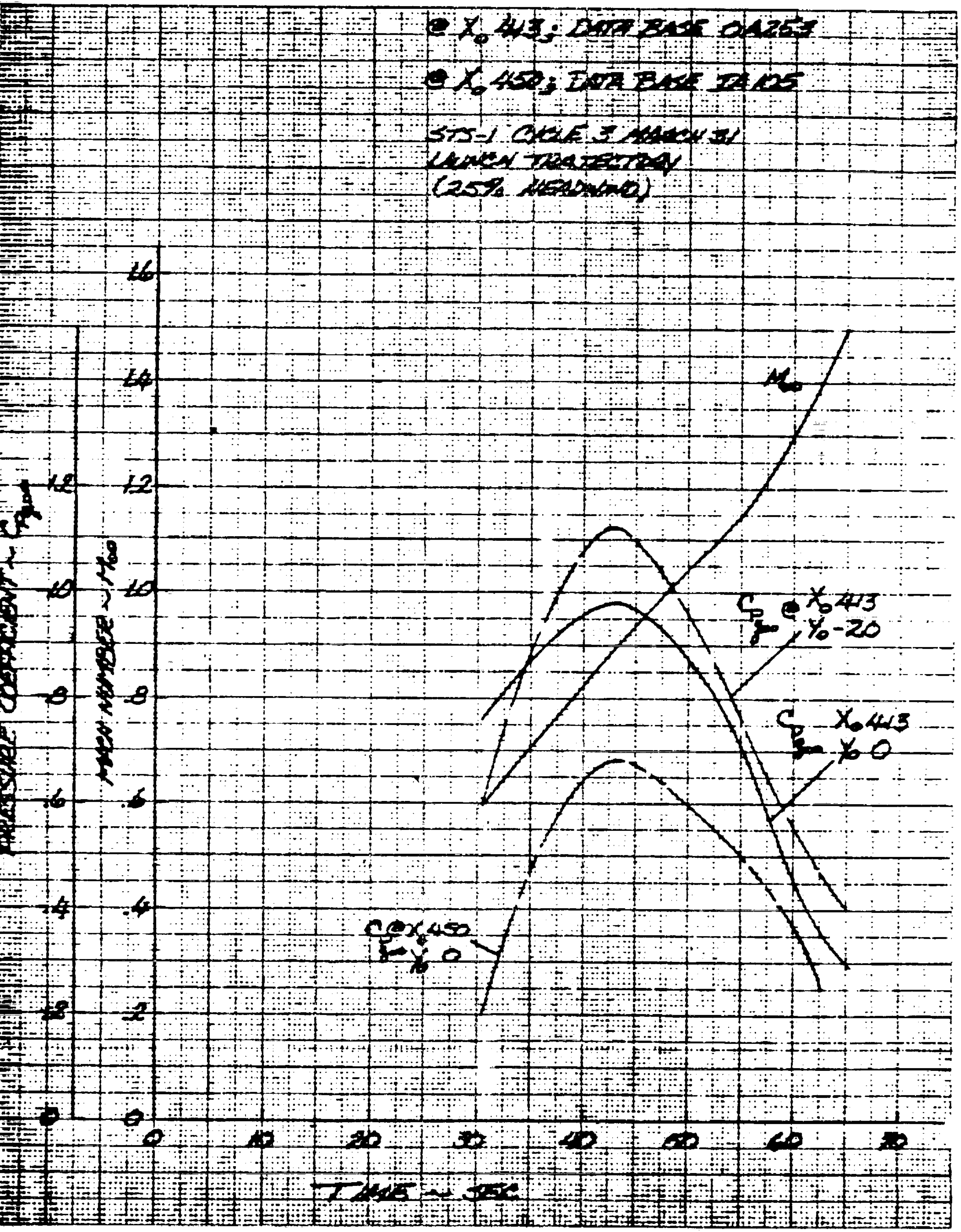


FIGURE 51 - ORBITER LOCAL FLOW CONDITIONS

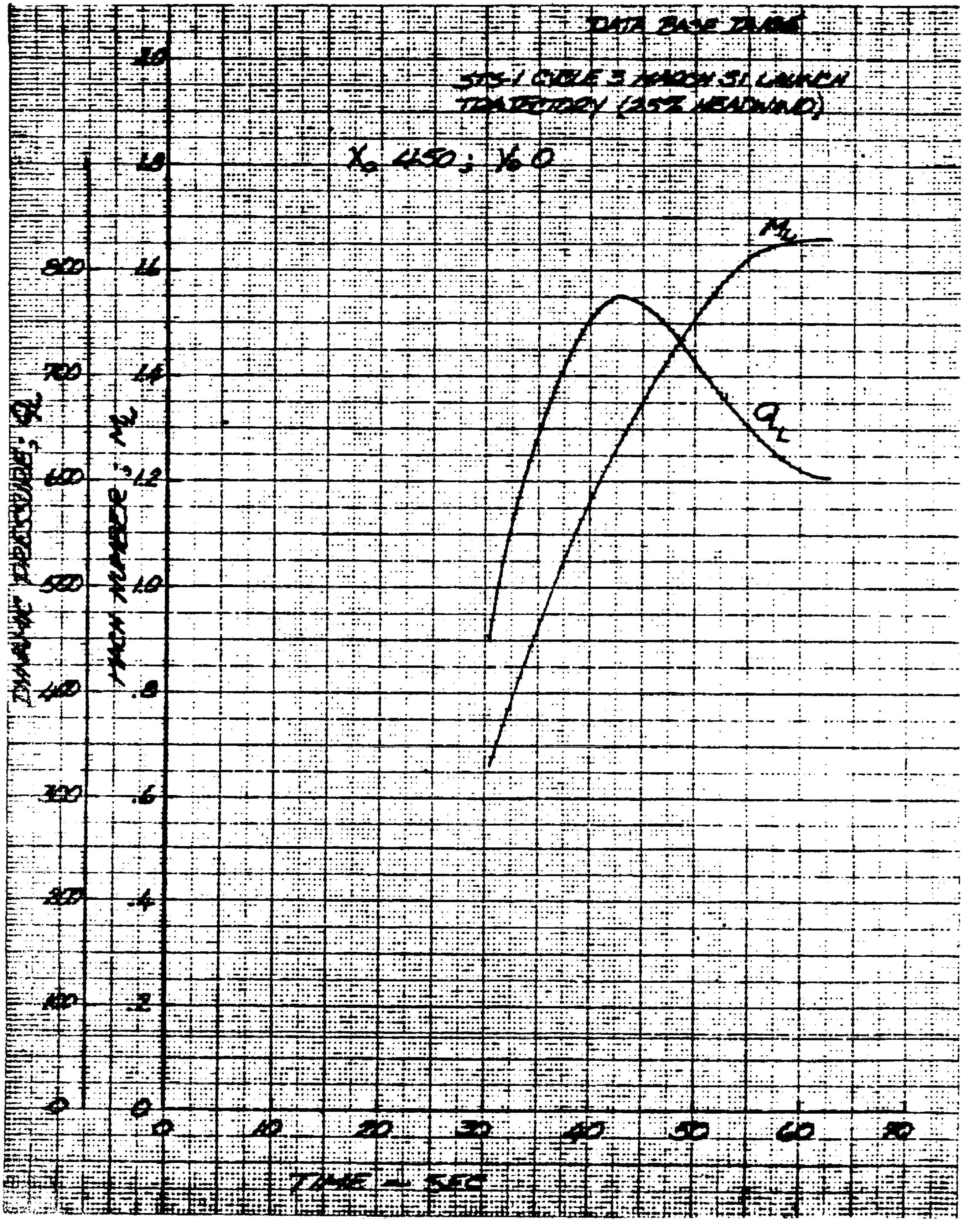


FIGURE 52 - ORBITER LOCAL FLOW CONDITIONS

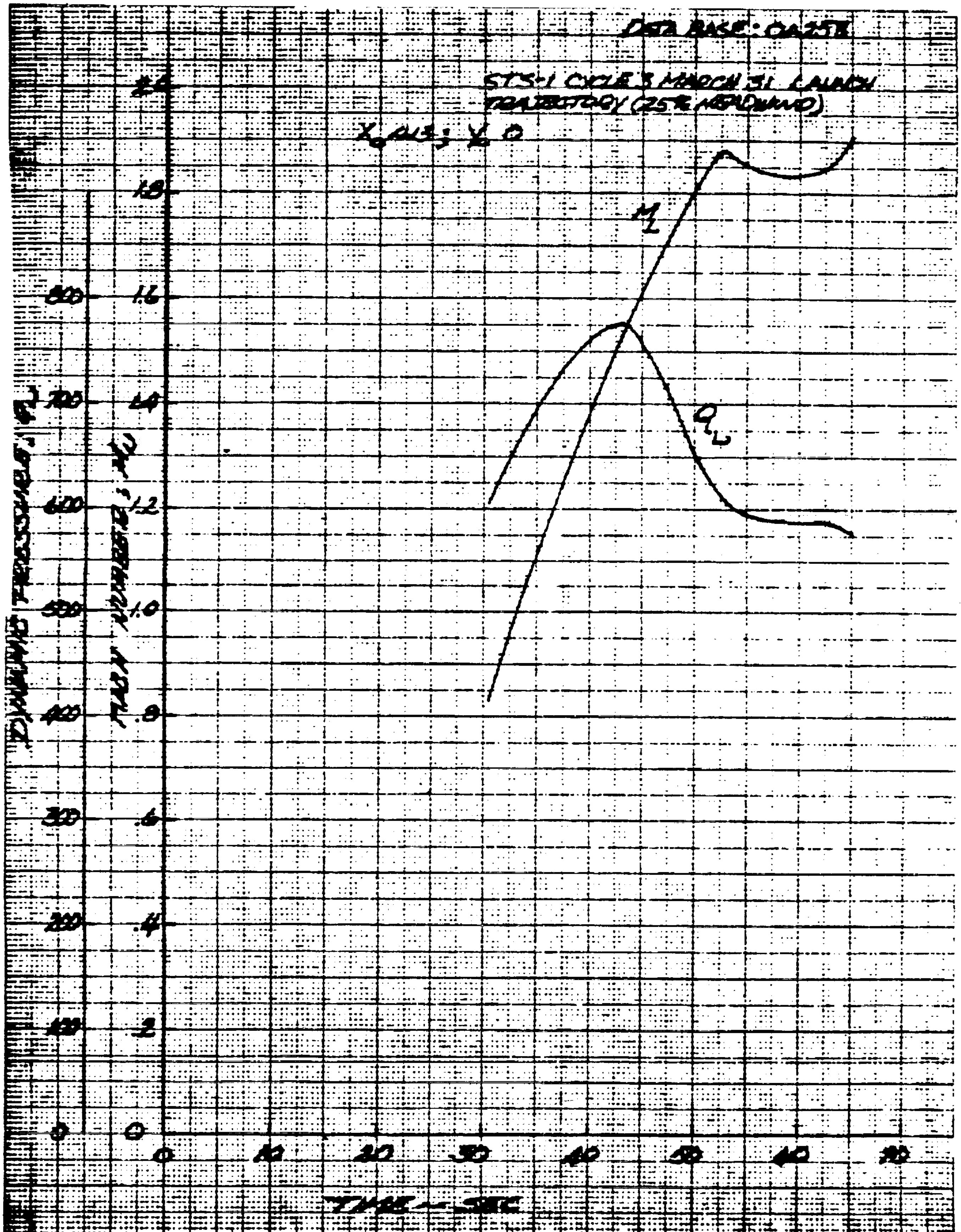


FIGURE 53 - ORBITER LOCAL FLOW CONDITIONS

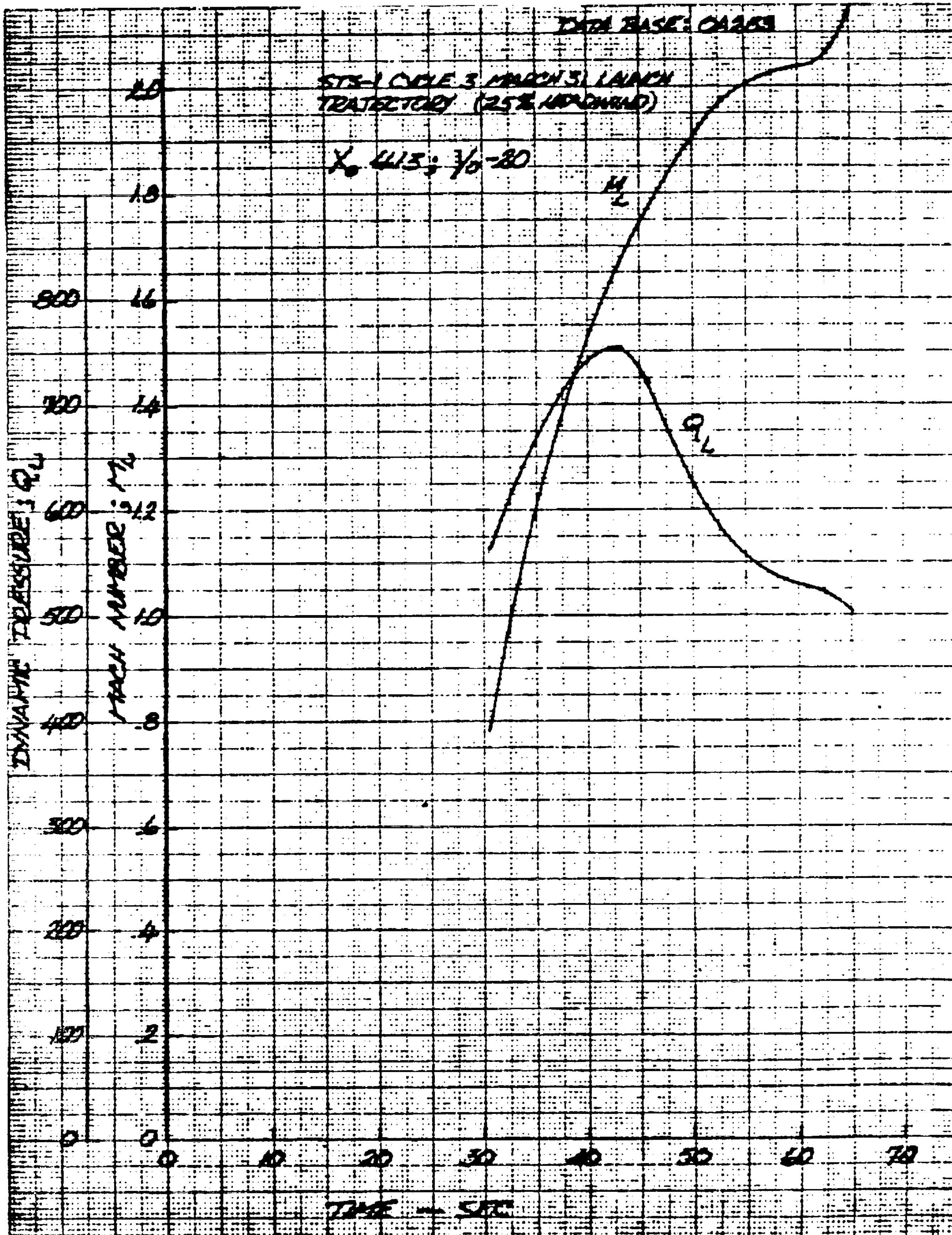


FIGURE 54 - ORBITER LOCAL FLOW CONDITIONS

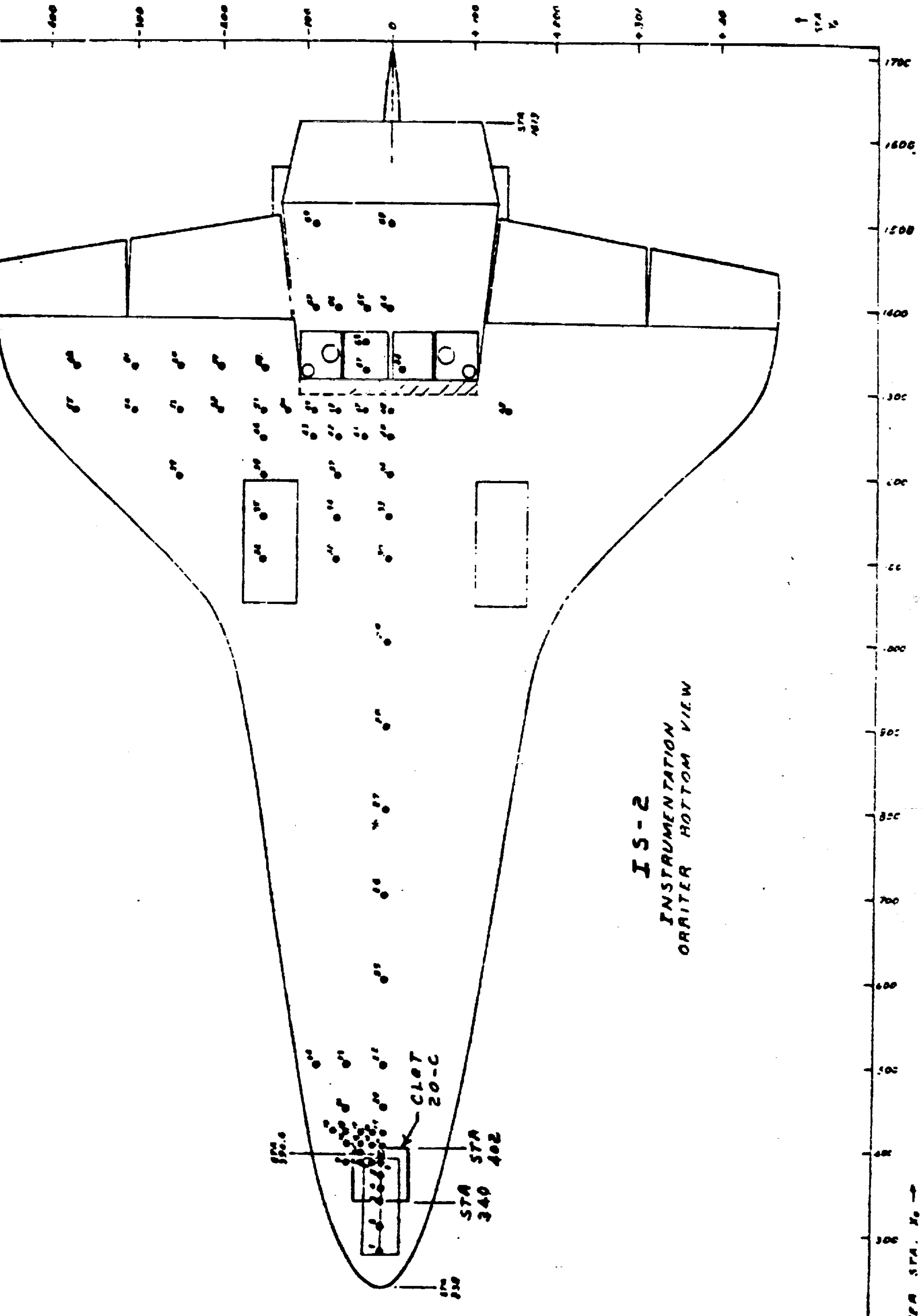
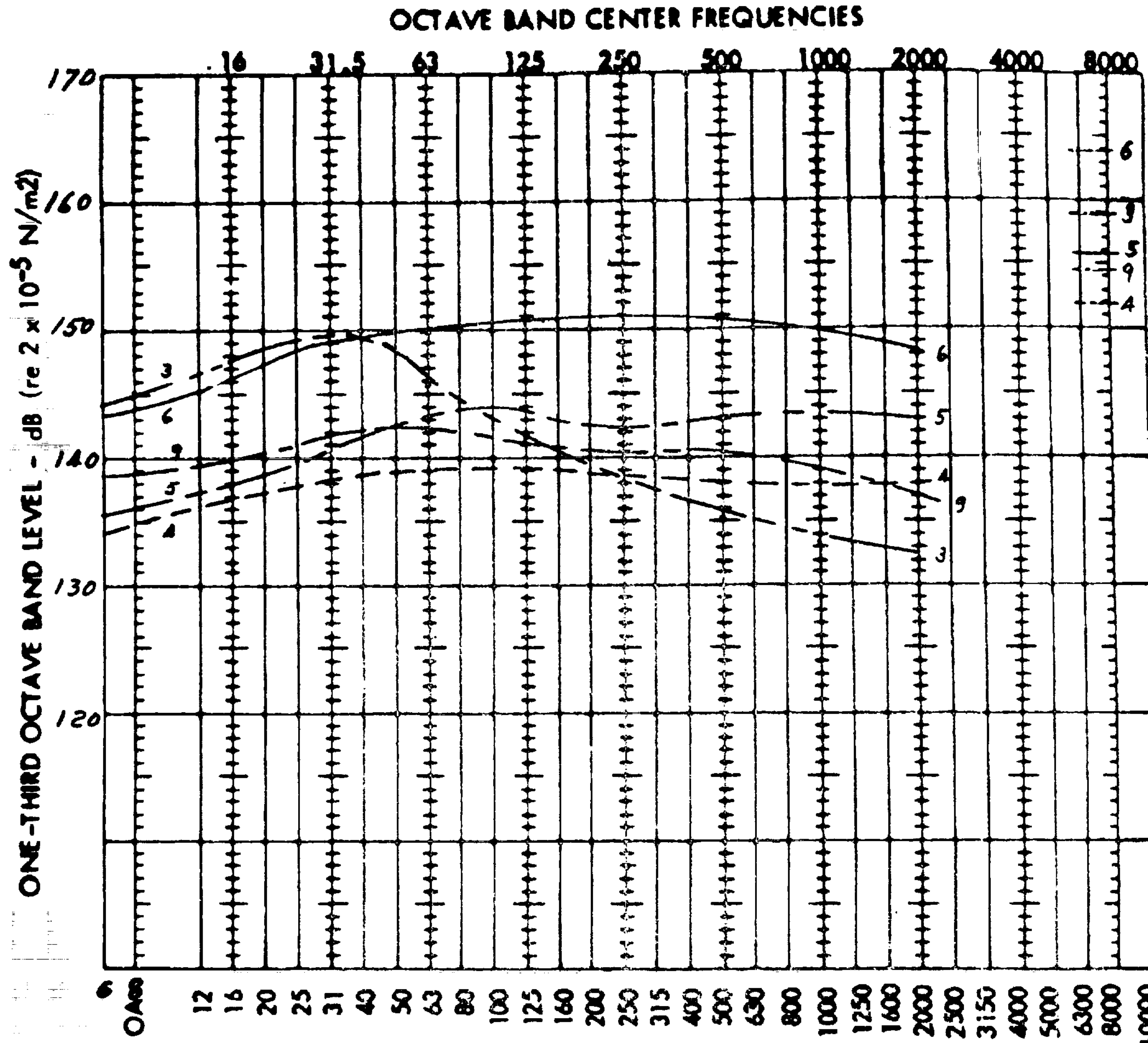


FIGURE 55 - ORBITER LOCAL FLOW CONDITIONS
FOR 20C PANELS



——— — — ——— MEAS 3 - X_o = 339, Y_o = 0

— — — — MEAS 4 - X_o = 354, Y_o = 0

——— — ——— MEAS 5 - X_o = 369, Y_o = 0

——————— MEAS 6 - X_o = 385, Y_o = 0

——— — ——— MEAS 9 X_o = 385, Y_o = -40

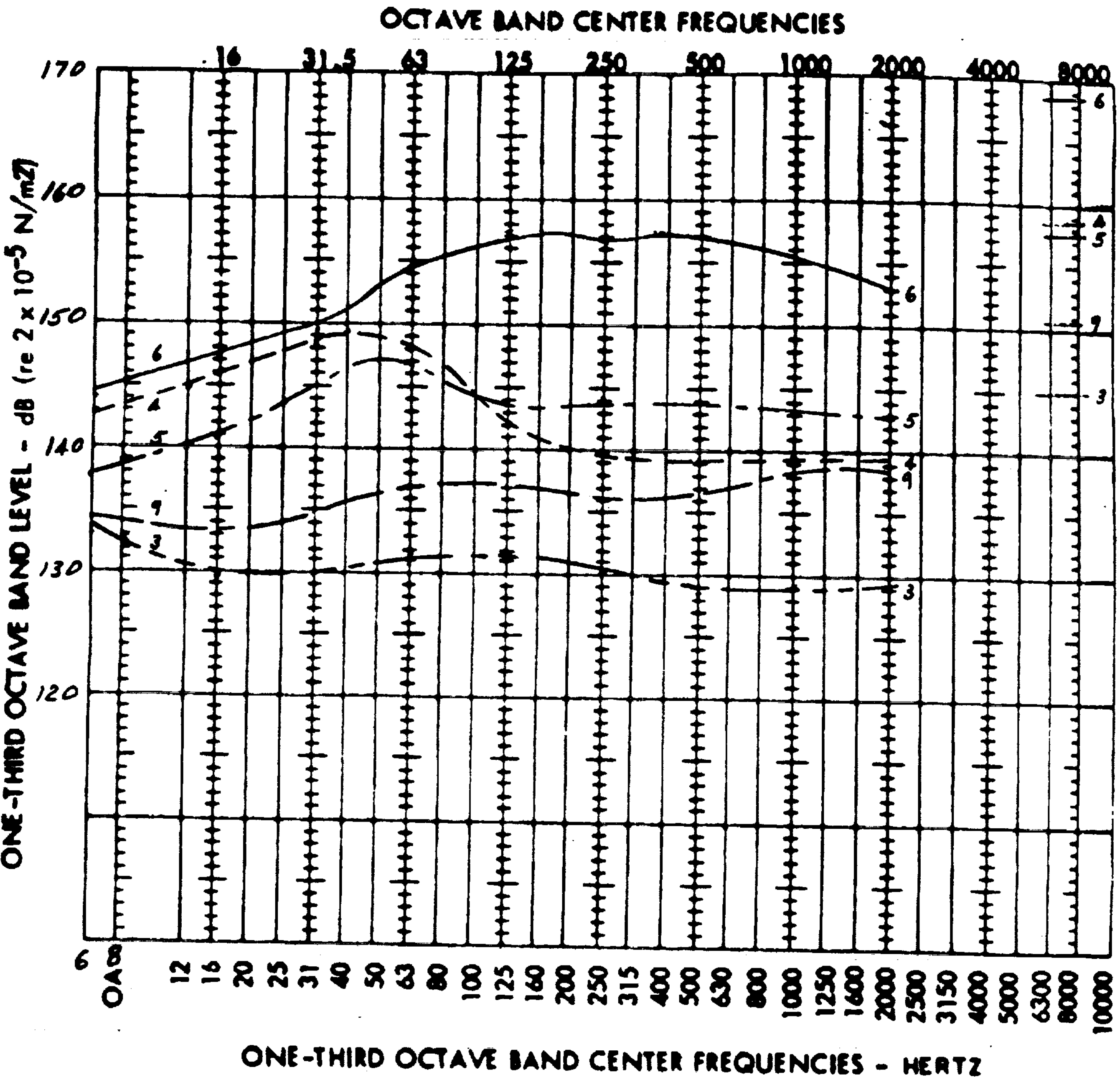
IS-2 DATA

MACH = 1.90

ALPHA = -1.1

BETA = 0.3

FIGURE 56 - ORBITER LOCAL FLOW CONDITIONS FOR 20C PANELS



—— - - —— MEAS 3 - $X_o = 339$, $Y_o = 0$

- - - - - - MEAS 4 - $X_o = 354$, $Y_o = 0$

—— - —— MEAS 5 $X_o = 369$, $Y_o = 0$

———— MEAS 6 $X_o = 385$, $Y_o = 0$

—— - —— MEAS 9 $X_o = 385$, $Y_o = -40$

IS-2 DATA

MACH = 2.10

ALPHA = -1.9

BETA = -0.4

FIGURE 57 - ORBITER LOCAL FLOW CONDITIONS FOR 20C PANELS

Exp. Jan. 31, 1977

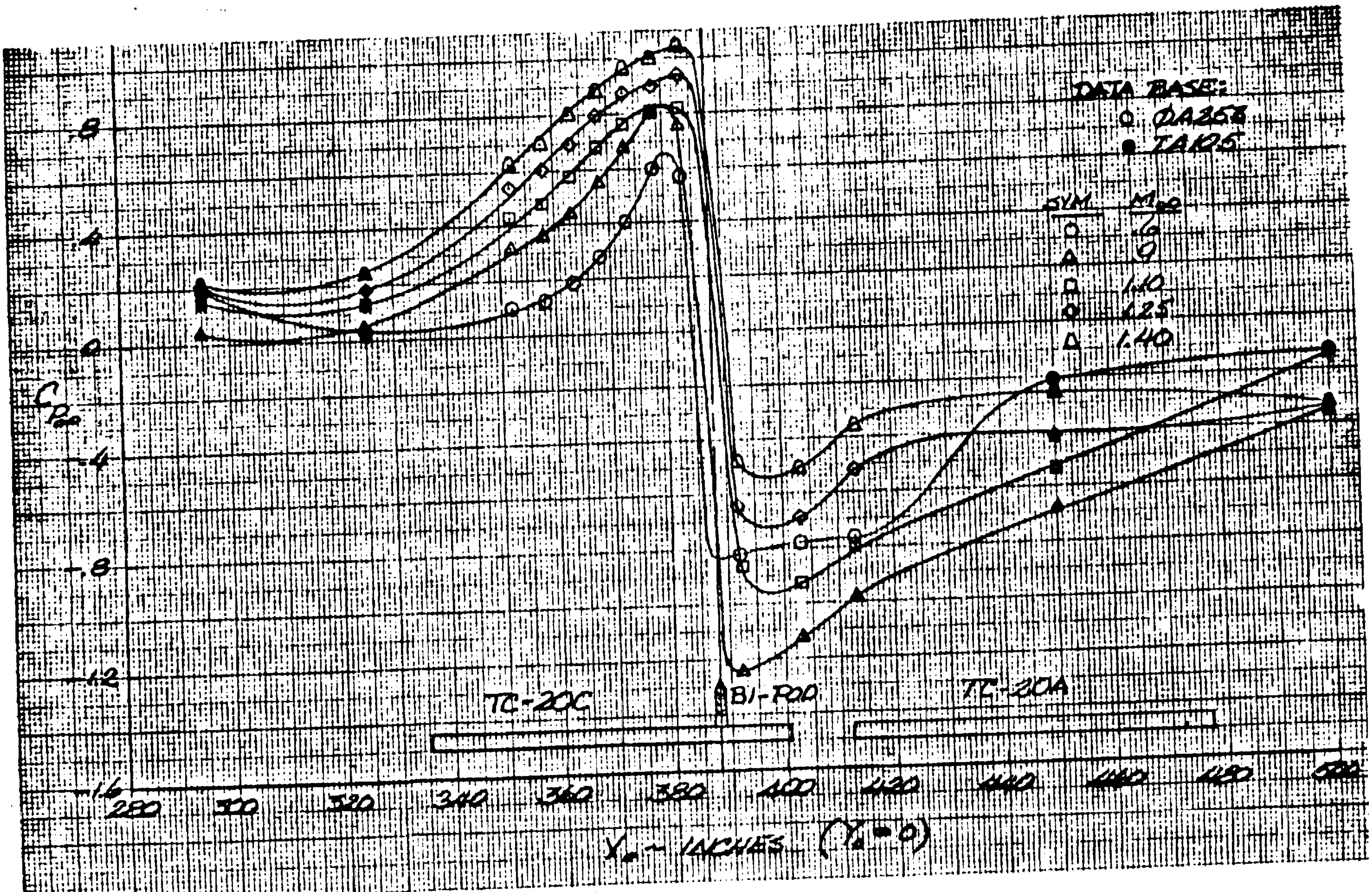


FIGURE 58 - ORBITER LOCAL FLOW CONDITIONS FOR 20C PANELS

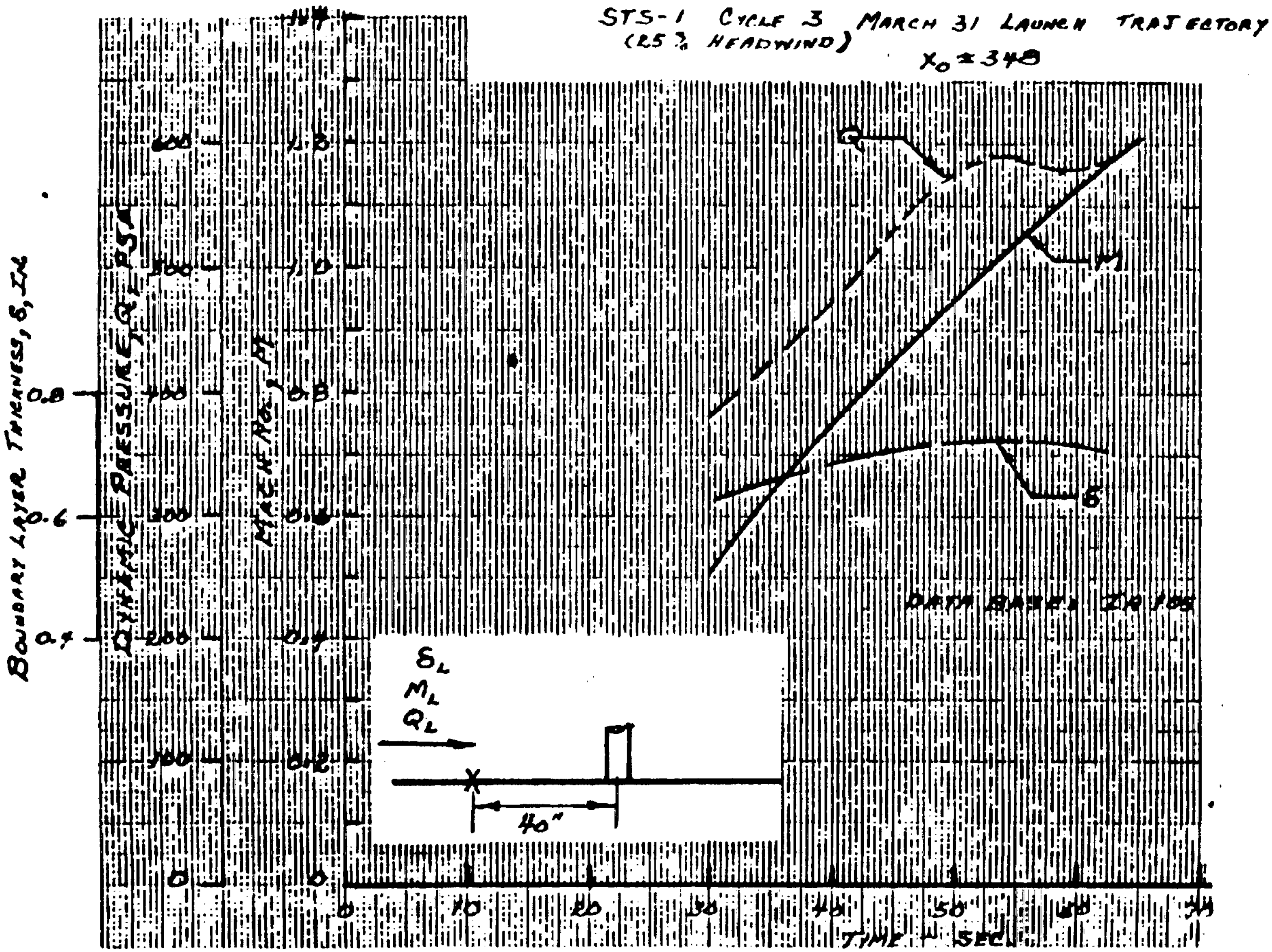


FIGURE 59 - ORBITER LOCAL FLOW CONDITIONS FOR 20C PANELS

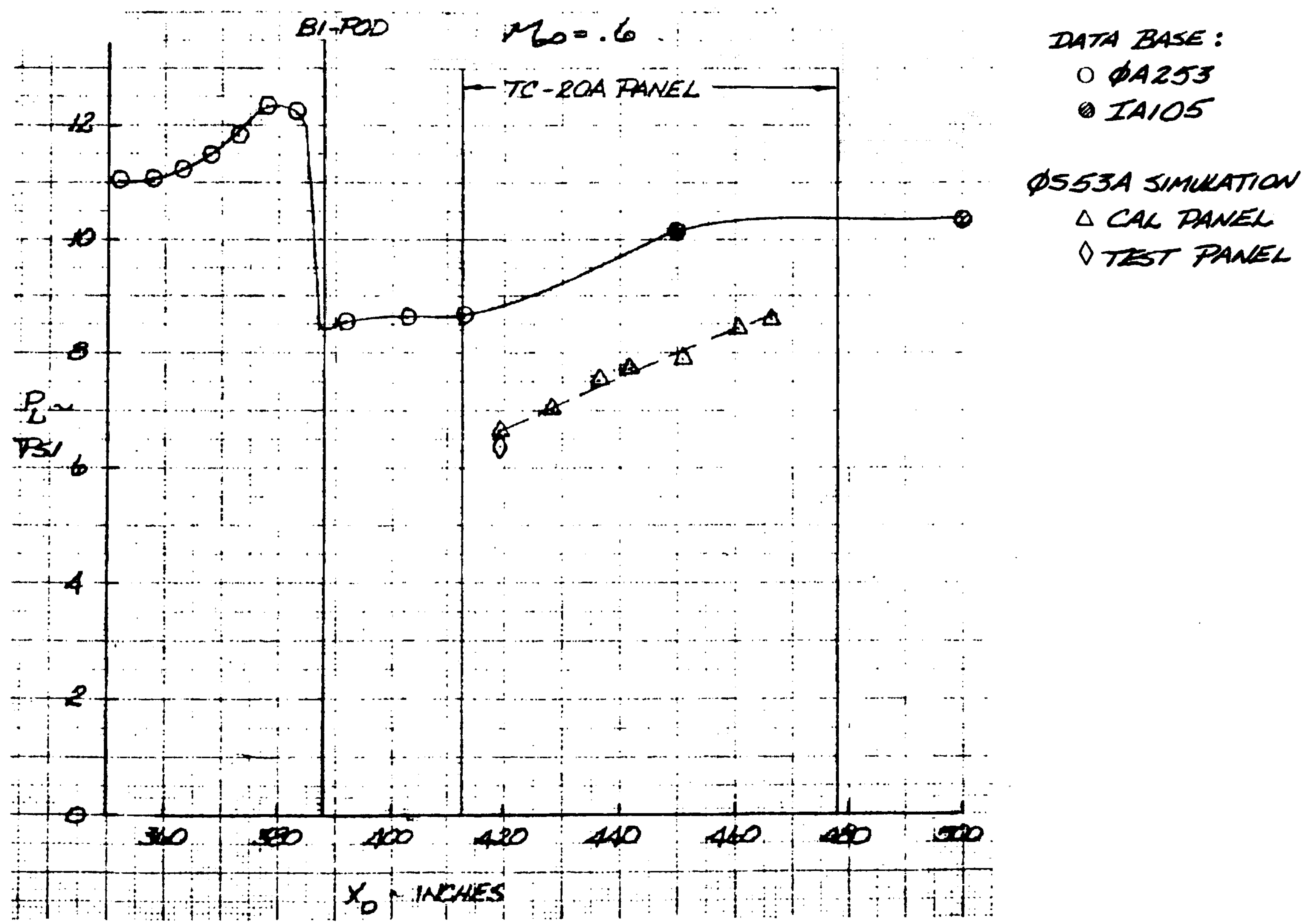


Figure 60a. CLOT Panel TC-20A Local Pressure Simulation ($M_{\infty} = 0.6$)

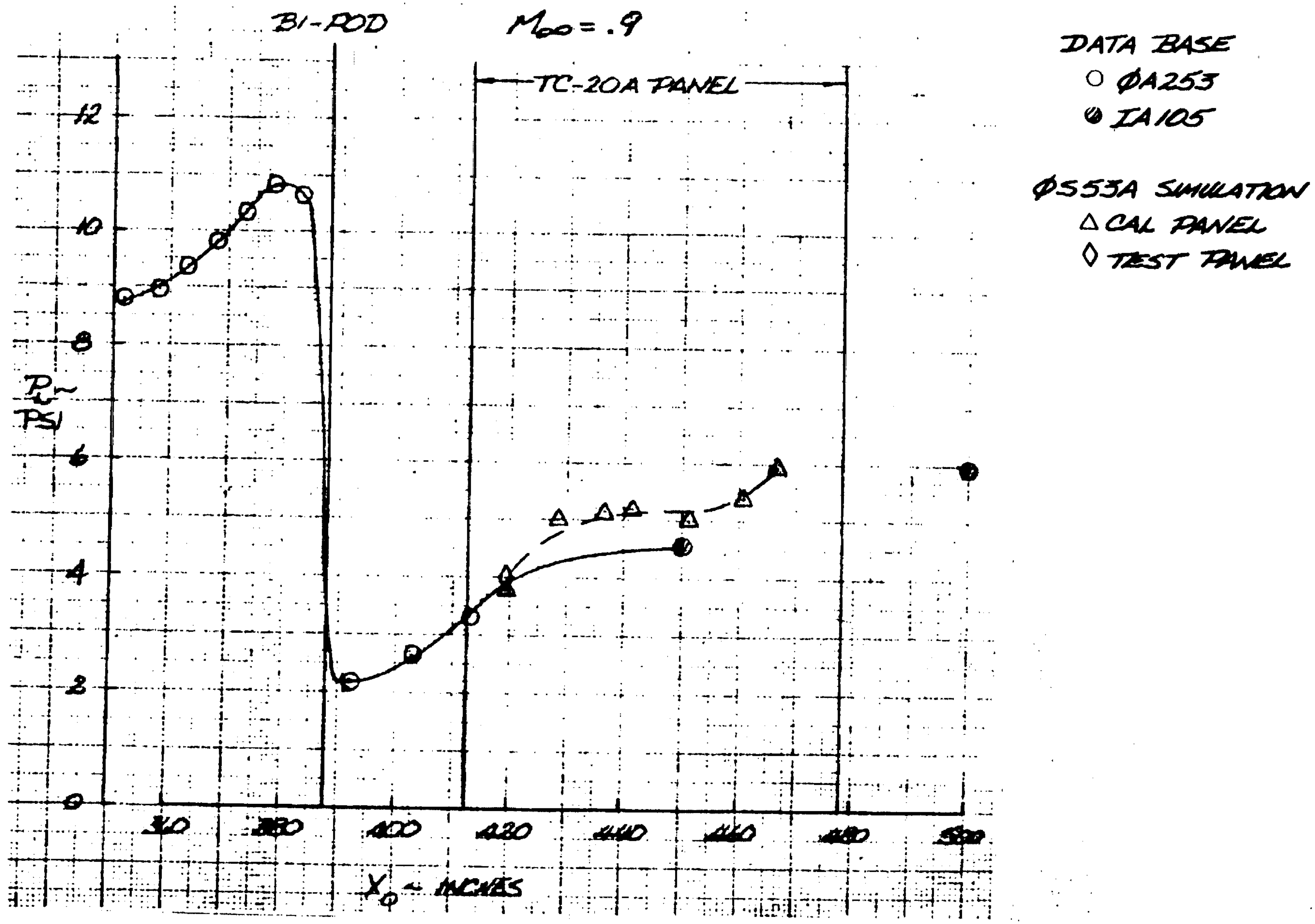
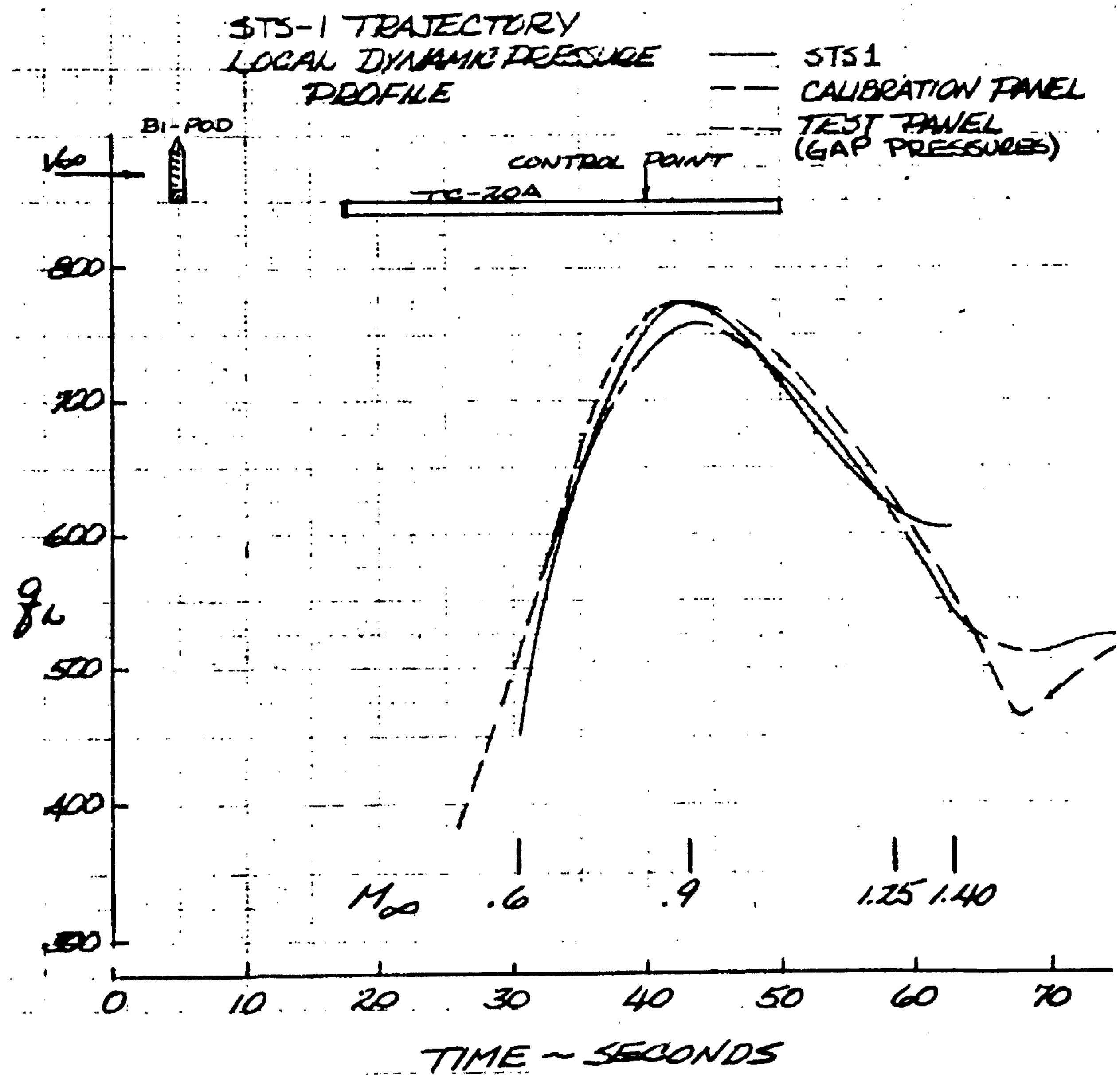


Figure 60b. CLOT Panel TC-20A Local Pressure Simulation (M$^\infty$ = .9)



STS-1 TRAJECTORY
LOCAL DYNAMIC PRESSURE
PROFILE
STS 1
CALIBRATION PANEL
TEST PANEL
(GAP PRESSURES)
BI-POD
CONTROL POINT
TC-20A
800
700
600
500
400
300
M_∞
.6
.9
1.25
1.40
0
10
20
30
40
50
60
70
TIME ~ SECONDS

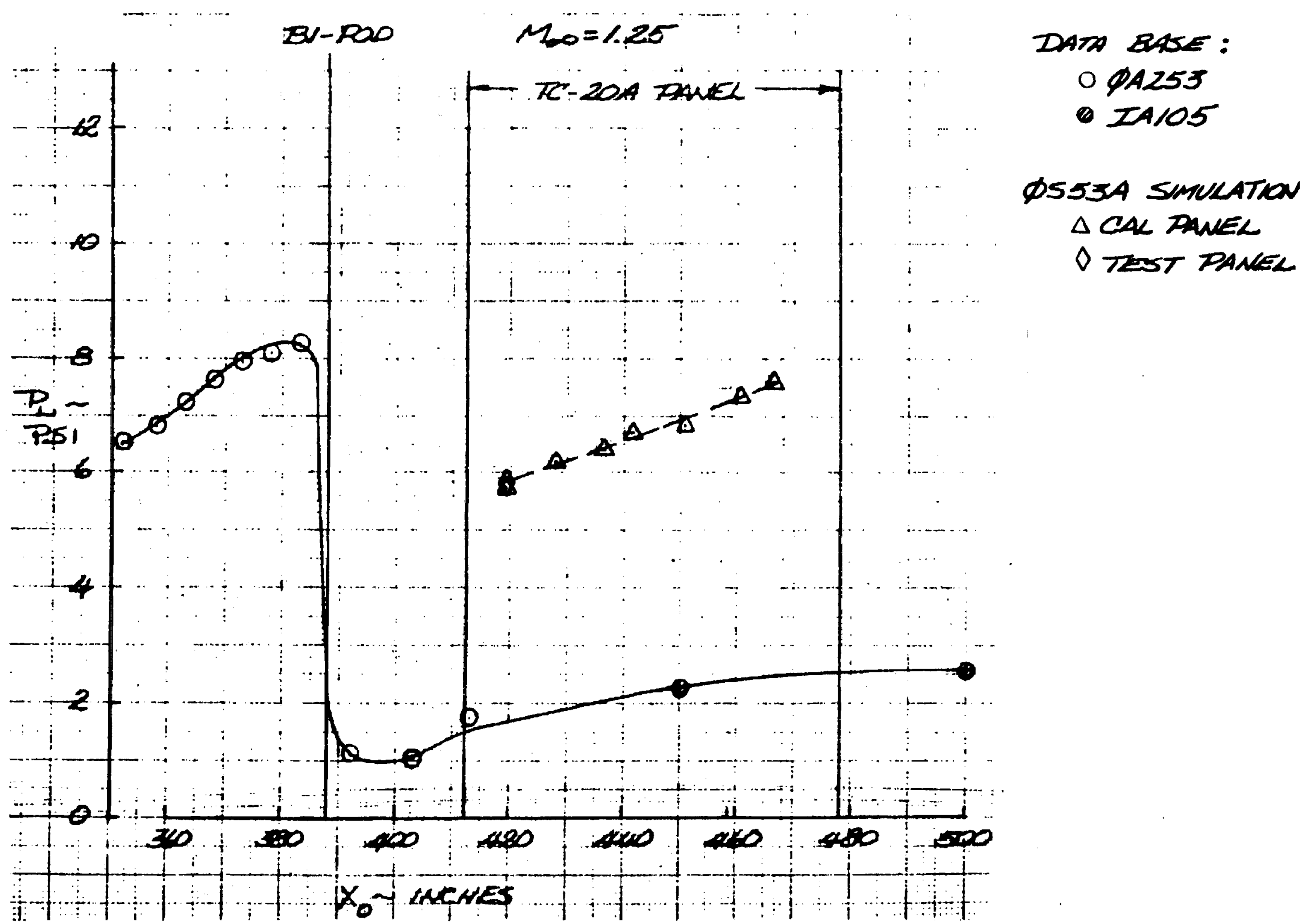


Figure 60d. CLOT Panel TC-20A Local Pressure Simulation (M_∞ = 1.25)

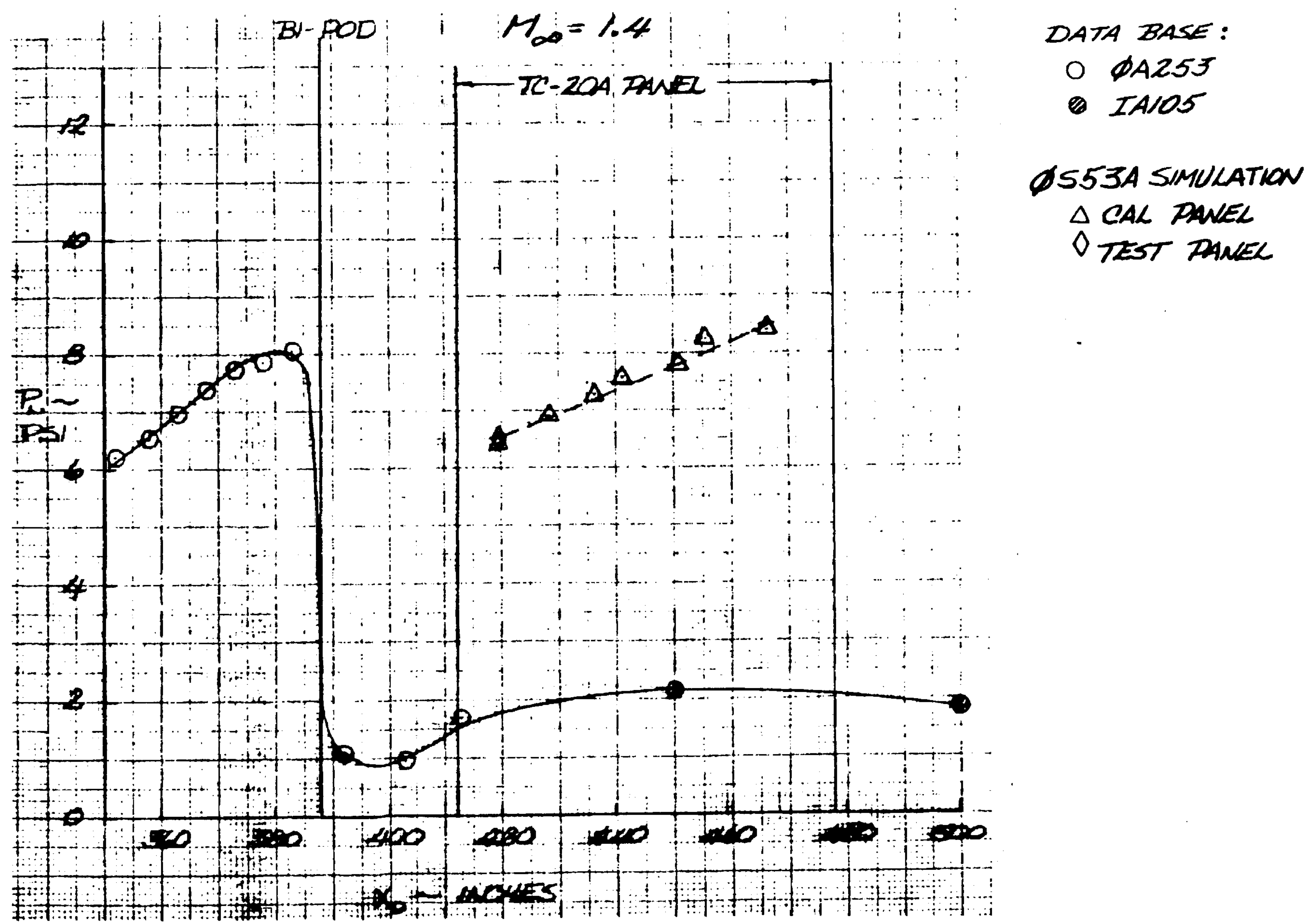


Figure 60e. CLOT Panel TC-20A Local Pressure Simulation ($M_\infty = 1.4$)

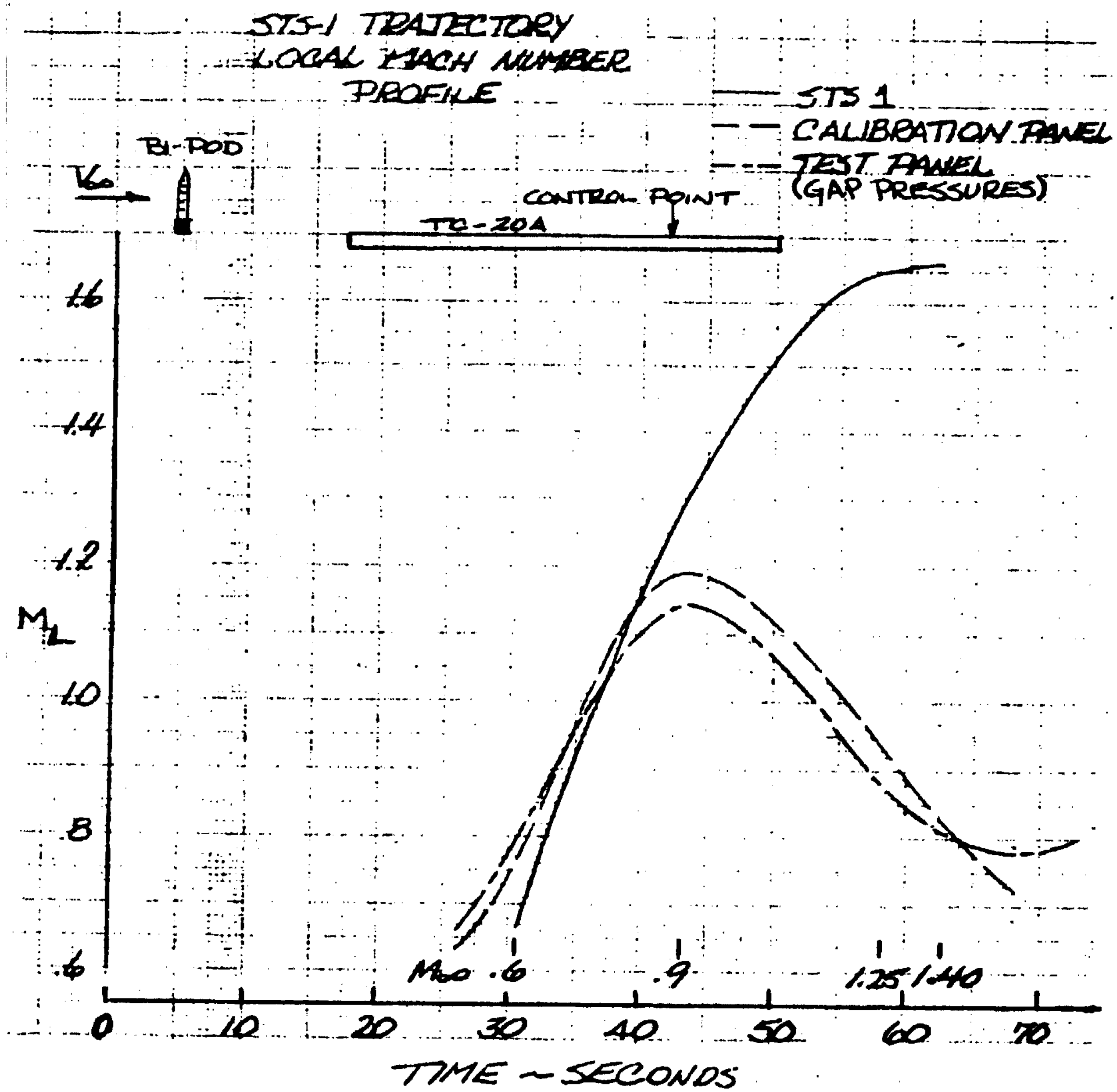
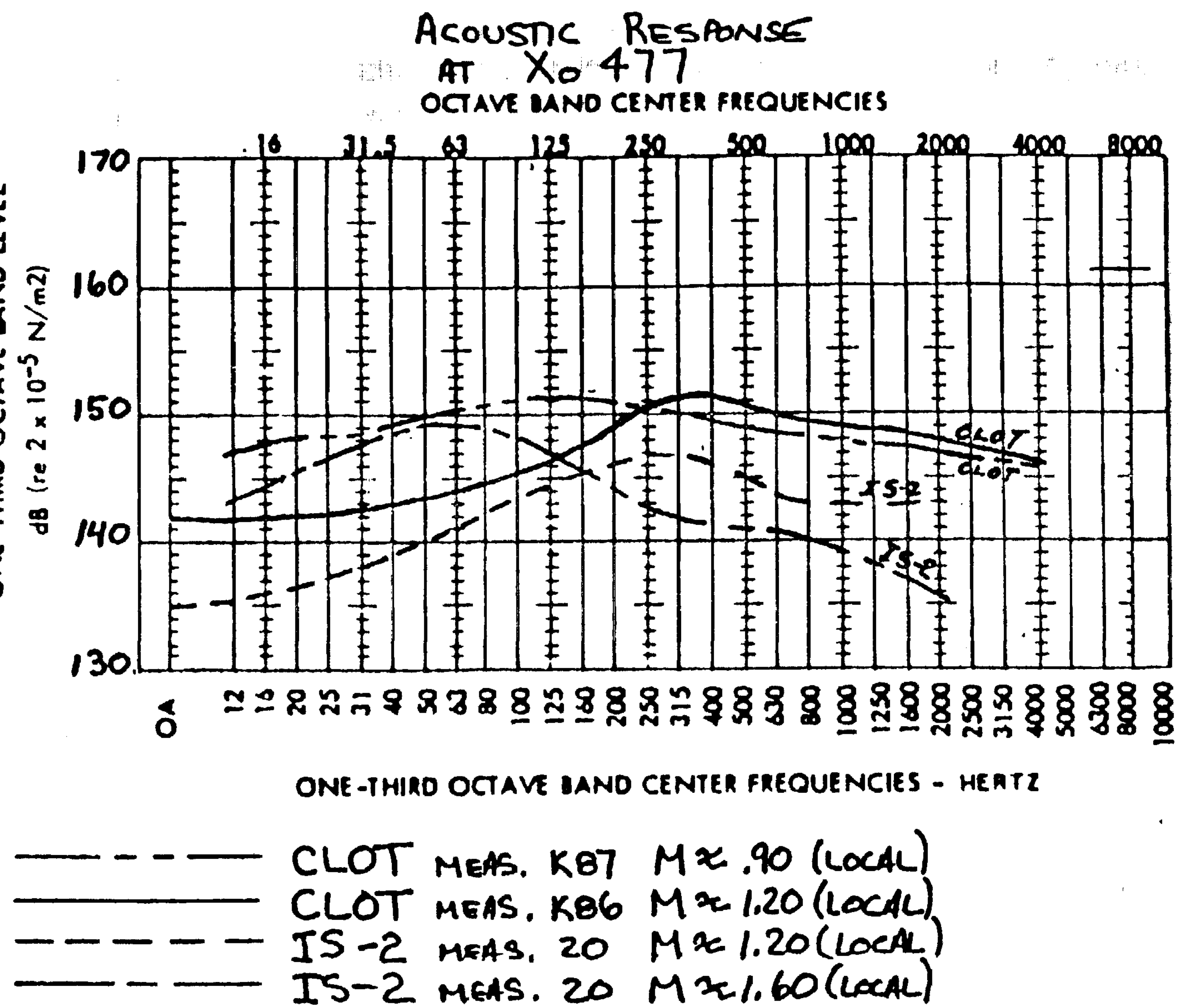


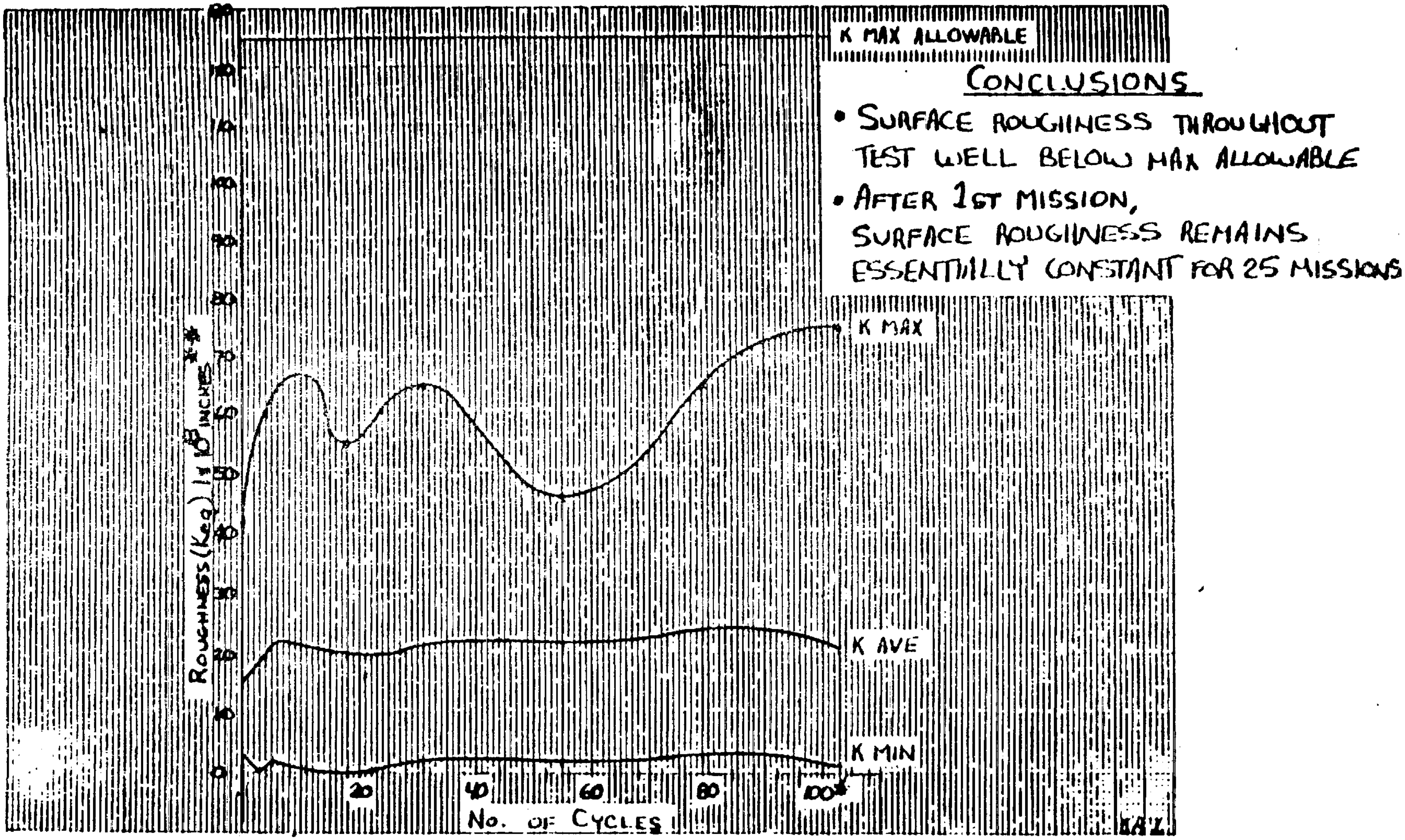
Figure 60f. CLOT Panel TC-20A Local Mach Number Simulation



CONCLUSIONS

- SHAKER SYSTEM ACHIEVED THE PRESCRIBED TOTAL VIBRATION ENERGY INPUT INTO TPS SYSTEM
- TOTAL AERO ENERGY INPUT TO SYSTEM MET OR EXCEEDED PRESCRIBED OV-102 MODEL LEVELS

Figure 60g. CLOT Panel TC-20A Local Dynamic Loads Summary



* 25 MISSION EQUIVALENTS (SCATTER FACTOR OF 4)

** COMPARISONS SHOWN FOR RANDOM SAMPLE 12.5 % OF TILES (5 OUT OF 40)

Figure 60h. CLOT Panel TC-20A Local Surface Roughness Comparison

RUN	CYC	CUM MISS
1	4	1
2	NO TEST	
3	5/9	2 3/4
4	7/16	4
5	3/19	4 3/4
6	9/28	7
7	24/52	13
8	24/76	19
9	24/100	25

FLOW DIRECTION

SINGLE TEST CYCLE

28 SEC	START UP
50 SEC	TEST
30 SEC	RUN DN
108 SEC	TOT

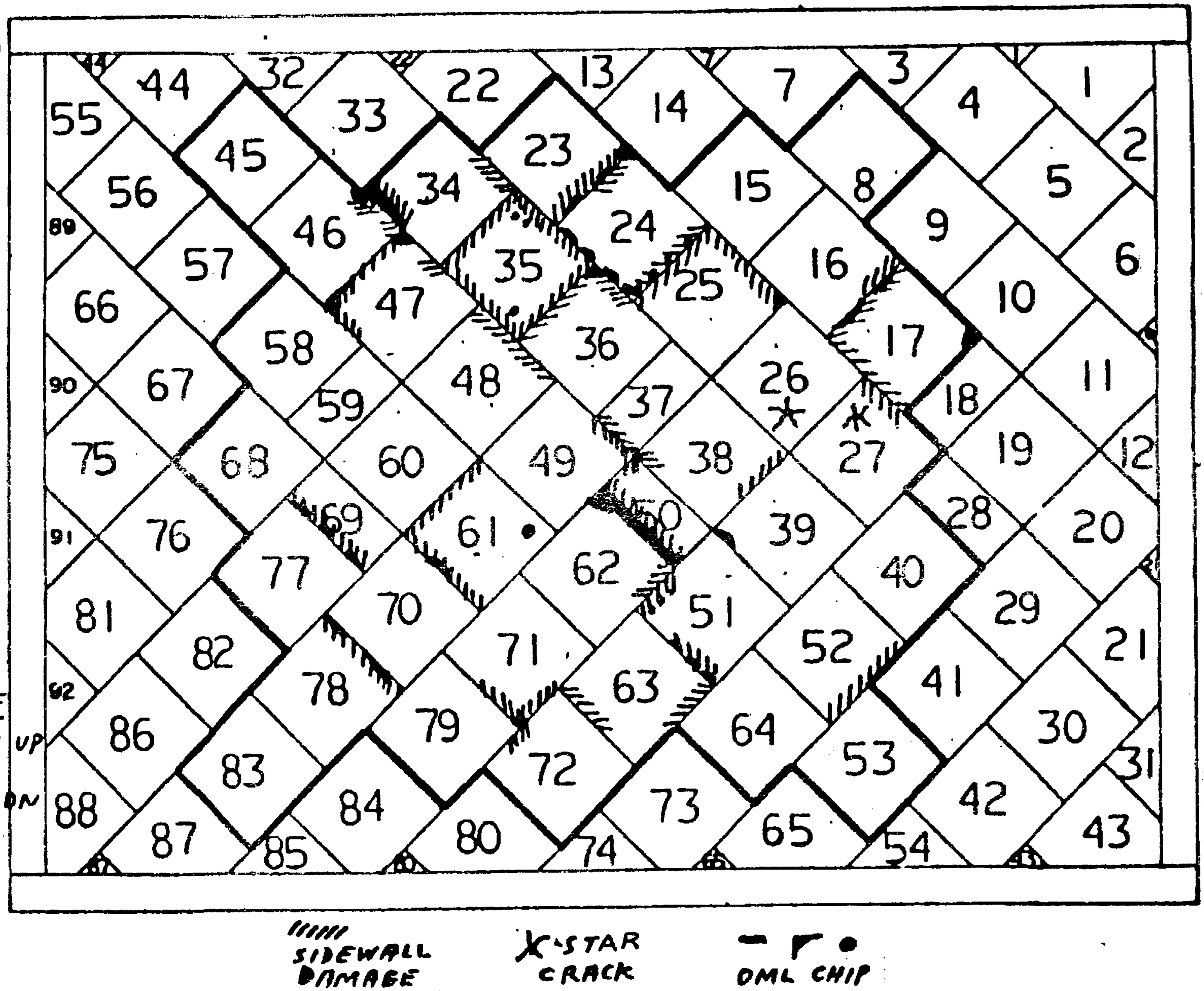


Figure 601. CLOT Panel TC-20A Cumulative Damage Map

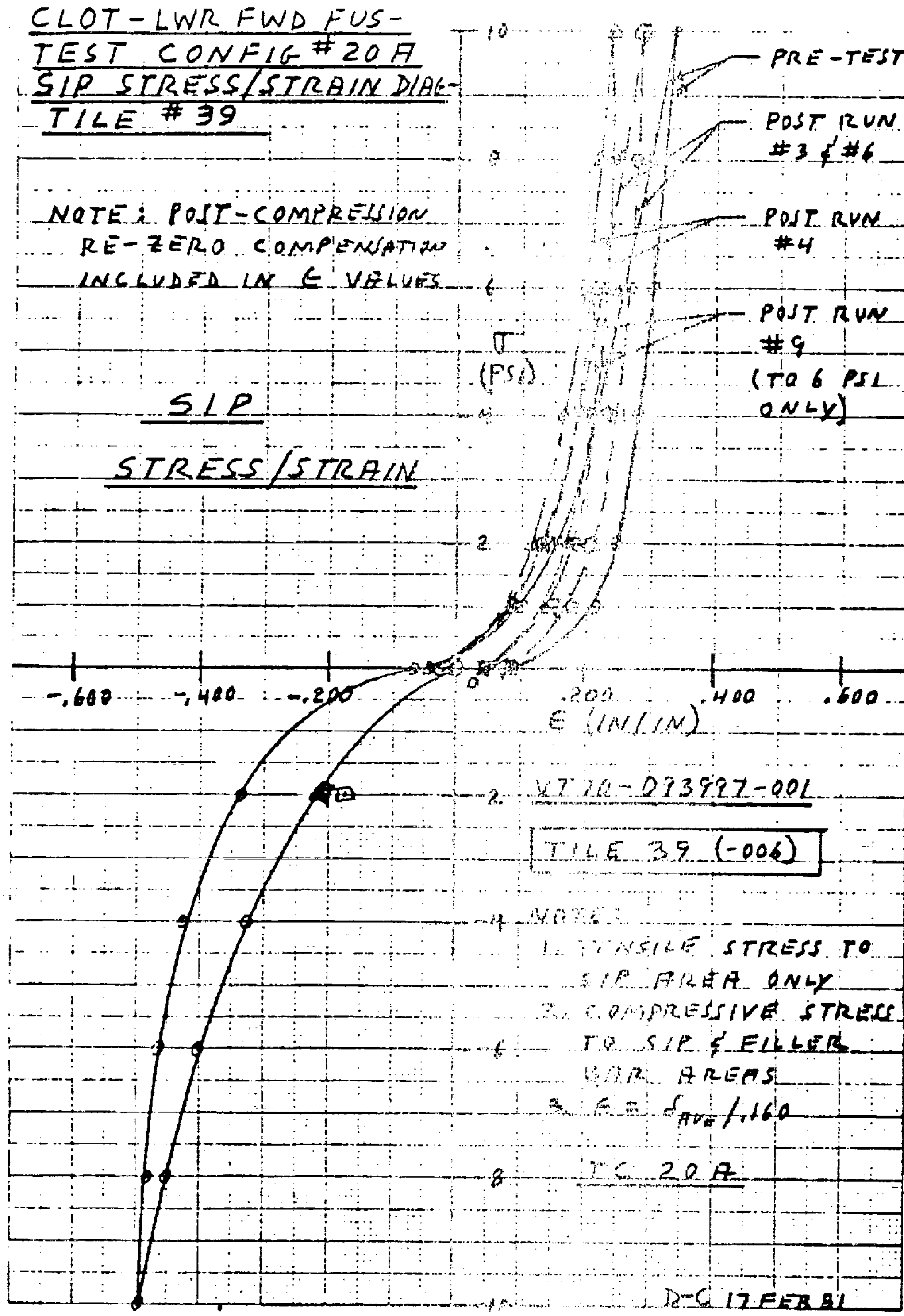


Figure 60j. CLOT Panel TC-20A SIP Stress/Strain Diagram, Tile #39

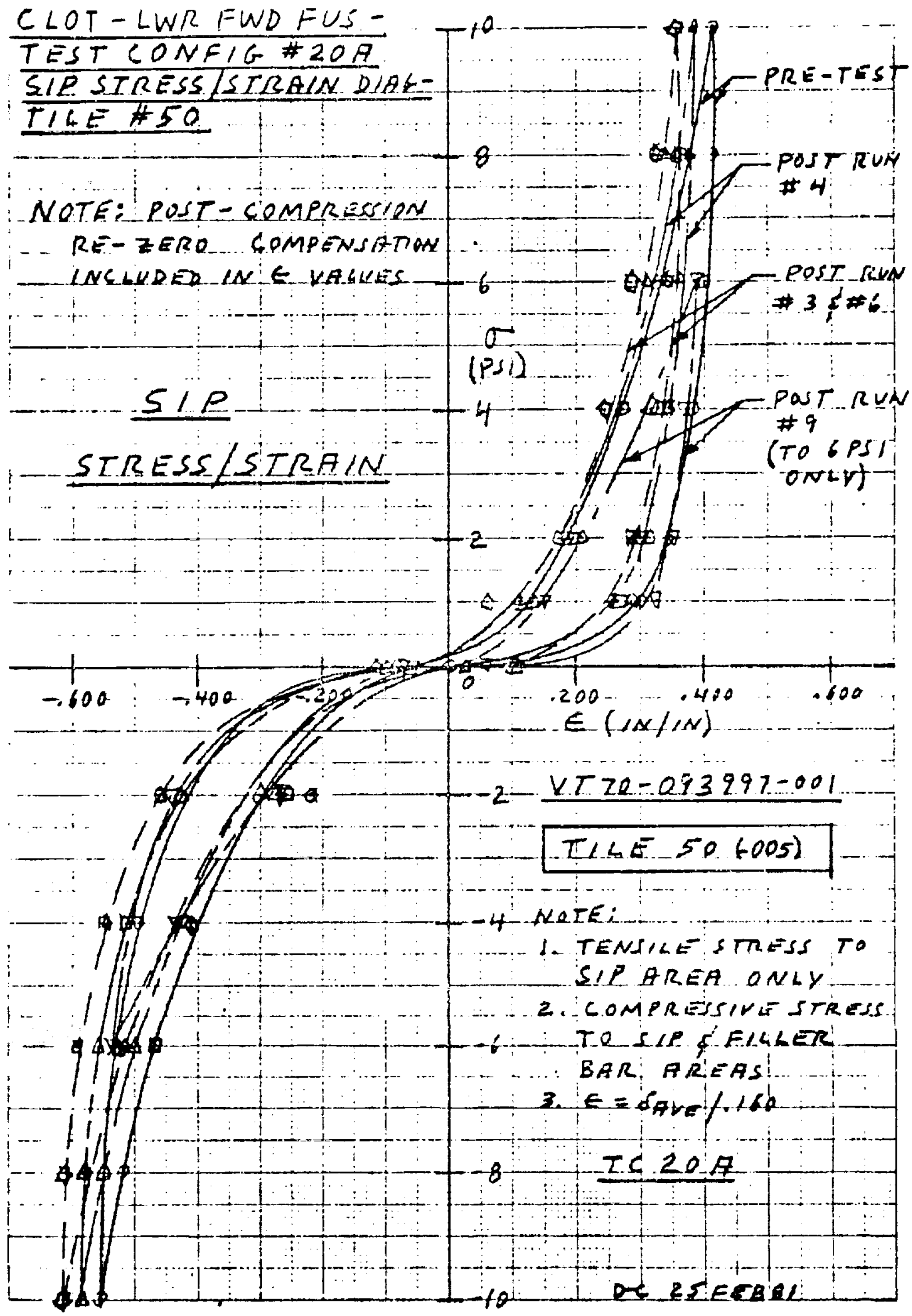


Figure 60k. CLOT Panel TC-20A SIP Stress/Strain Diagram, Tile #50

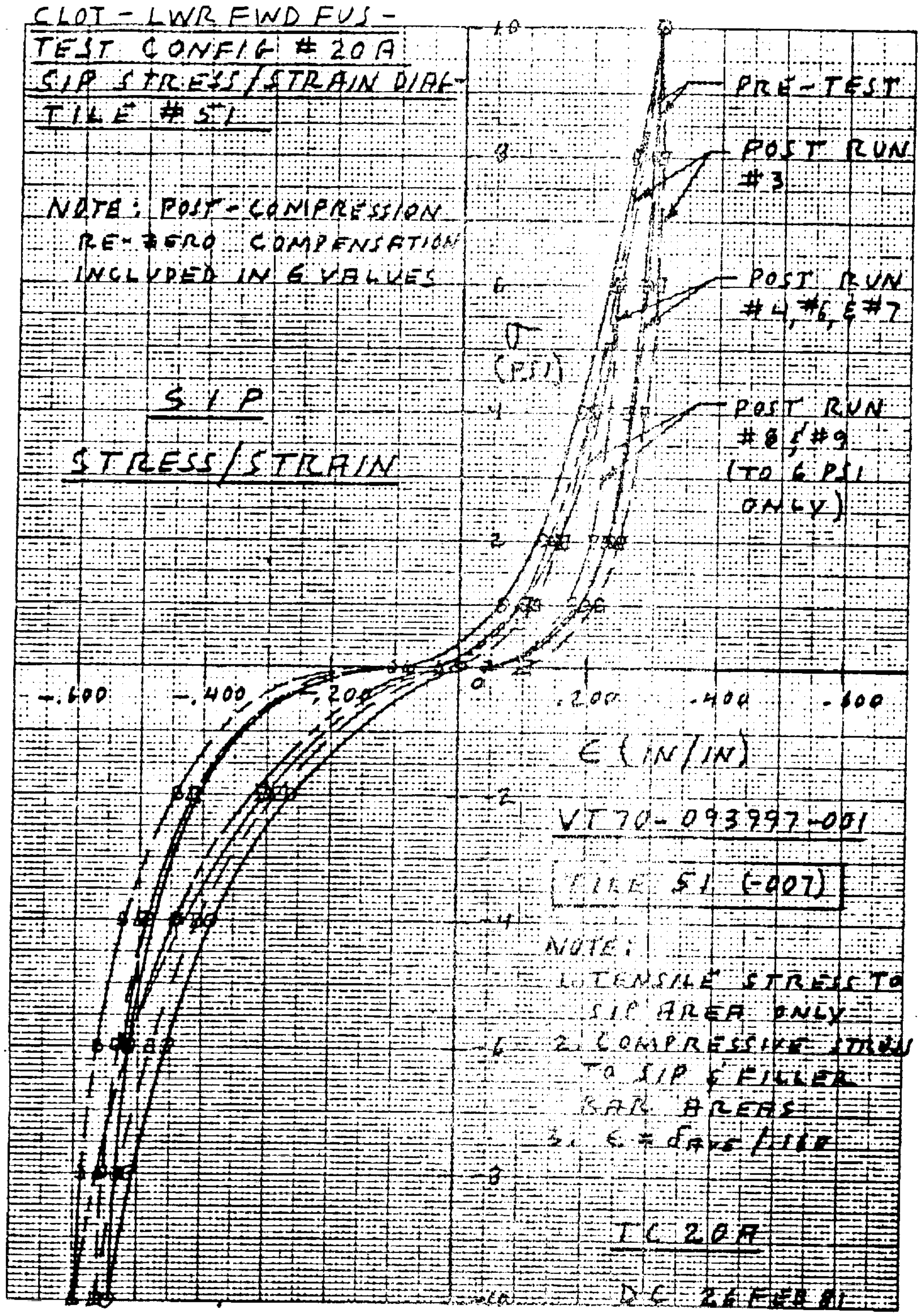


Figure 601. CLOT Panel TC-20A SIP Stress/Strain Diagram, Tile #51

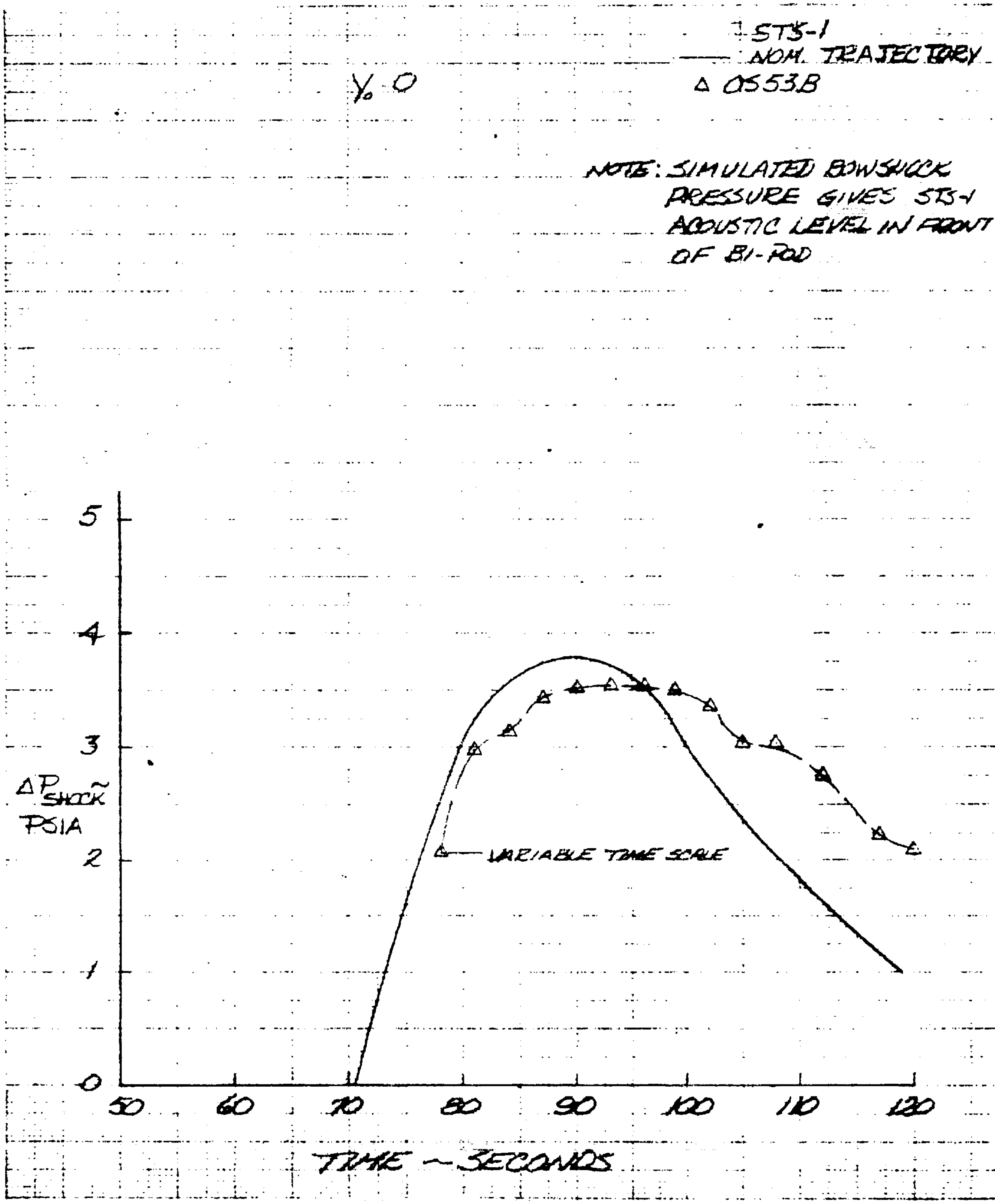


Figure 60m. CLOT Test Panel TC-20C, Simulation of Bow Shock for STS-1

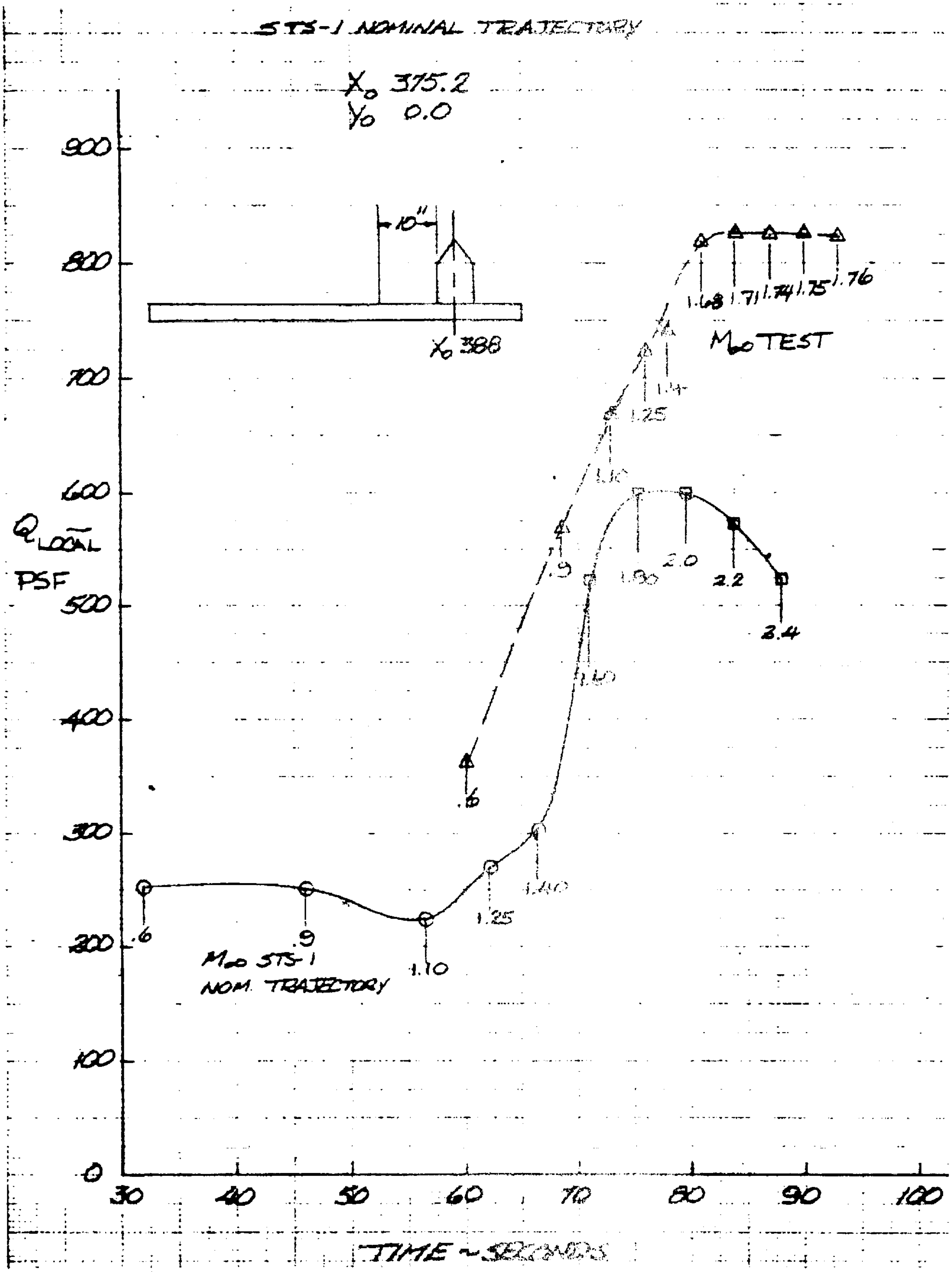


Figure 60n. CLOT Test Panel TC-20C, Local Dynamic Pressure Time History

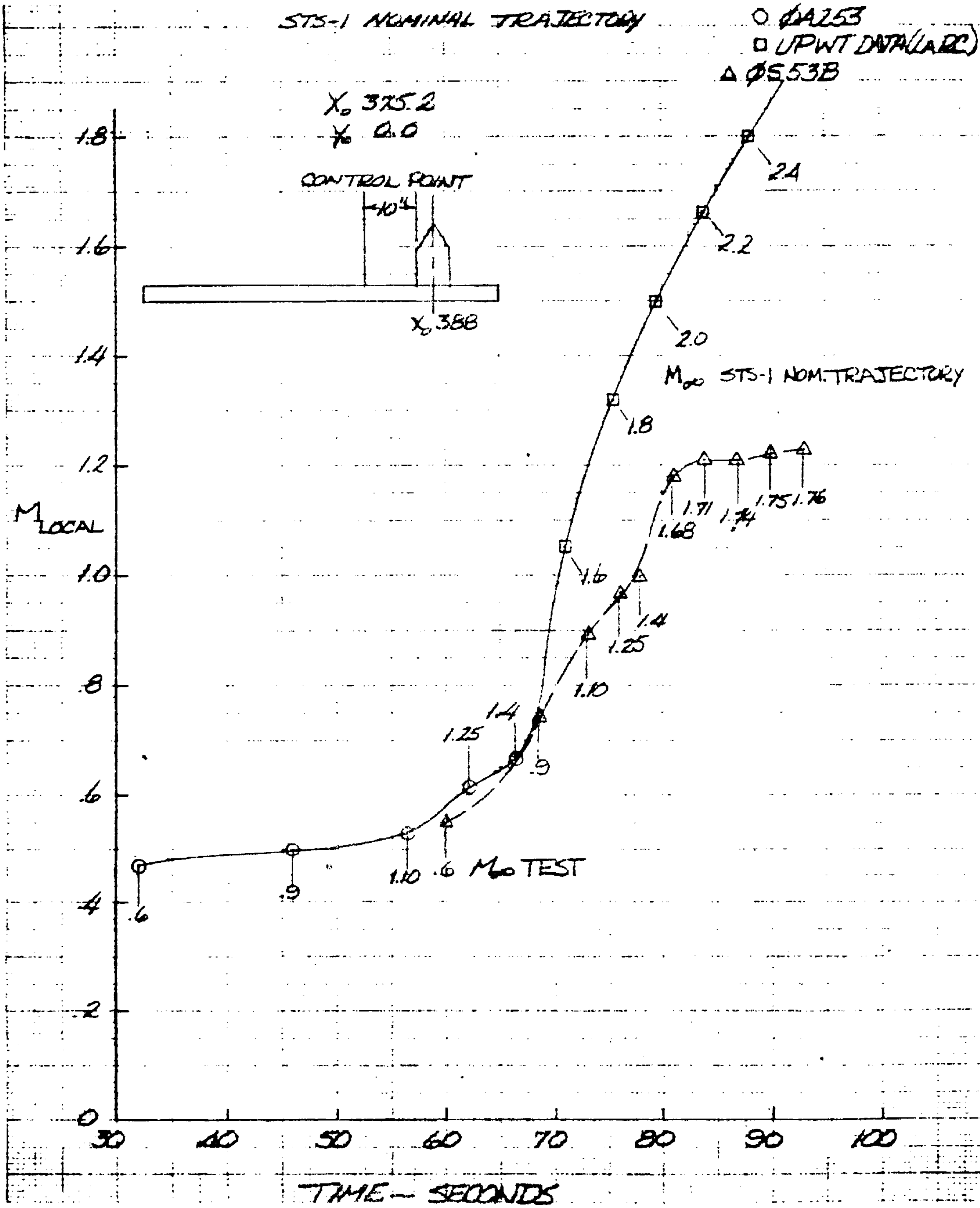


Figure 60o. CLOT Test Panel TC-20C, Local Mach Number Time History

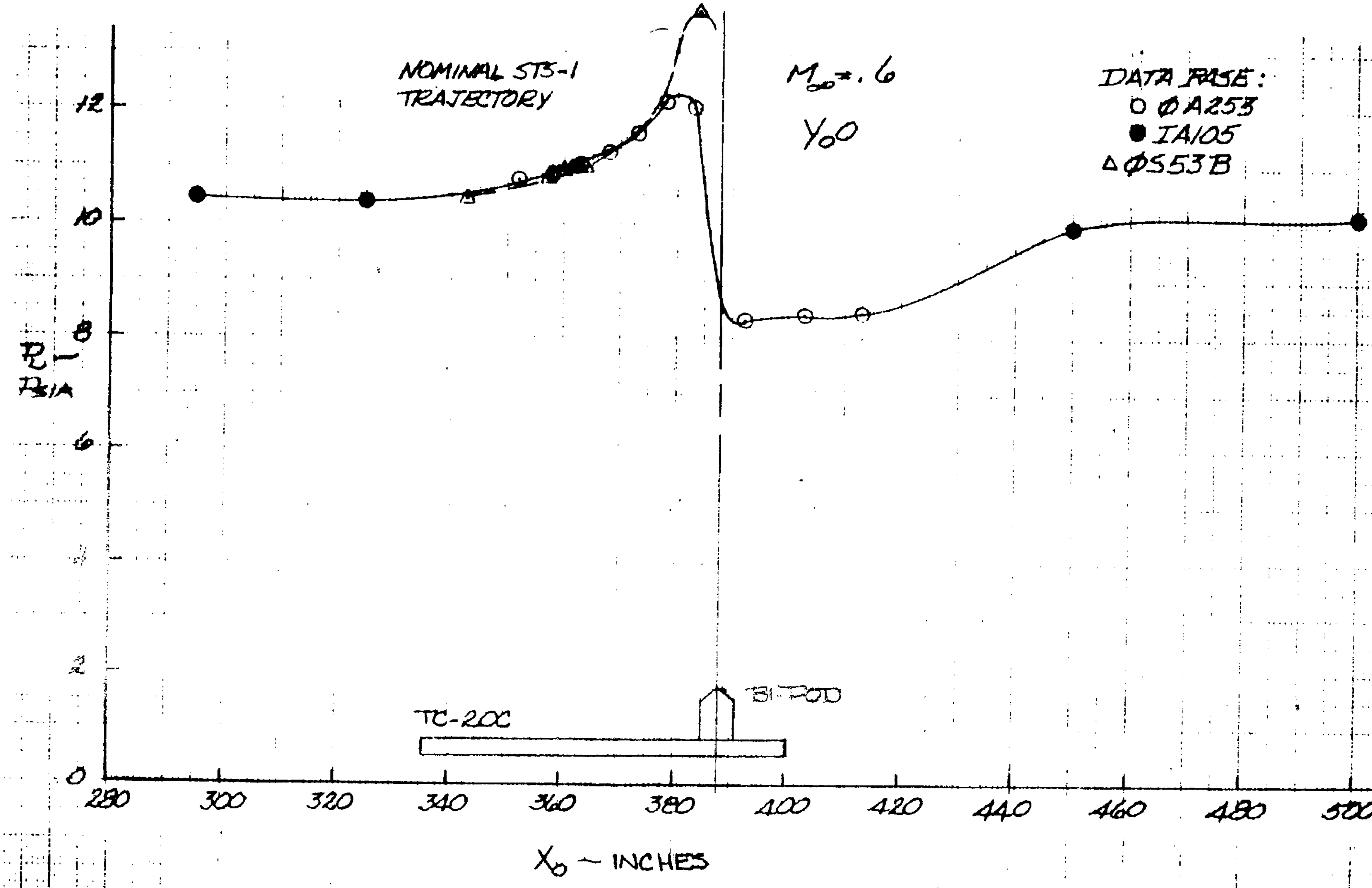


Figure 60p. CLOT Test Panel TC-20C, Pressure Distribution (M_∞ = 0.6)

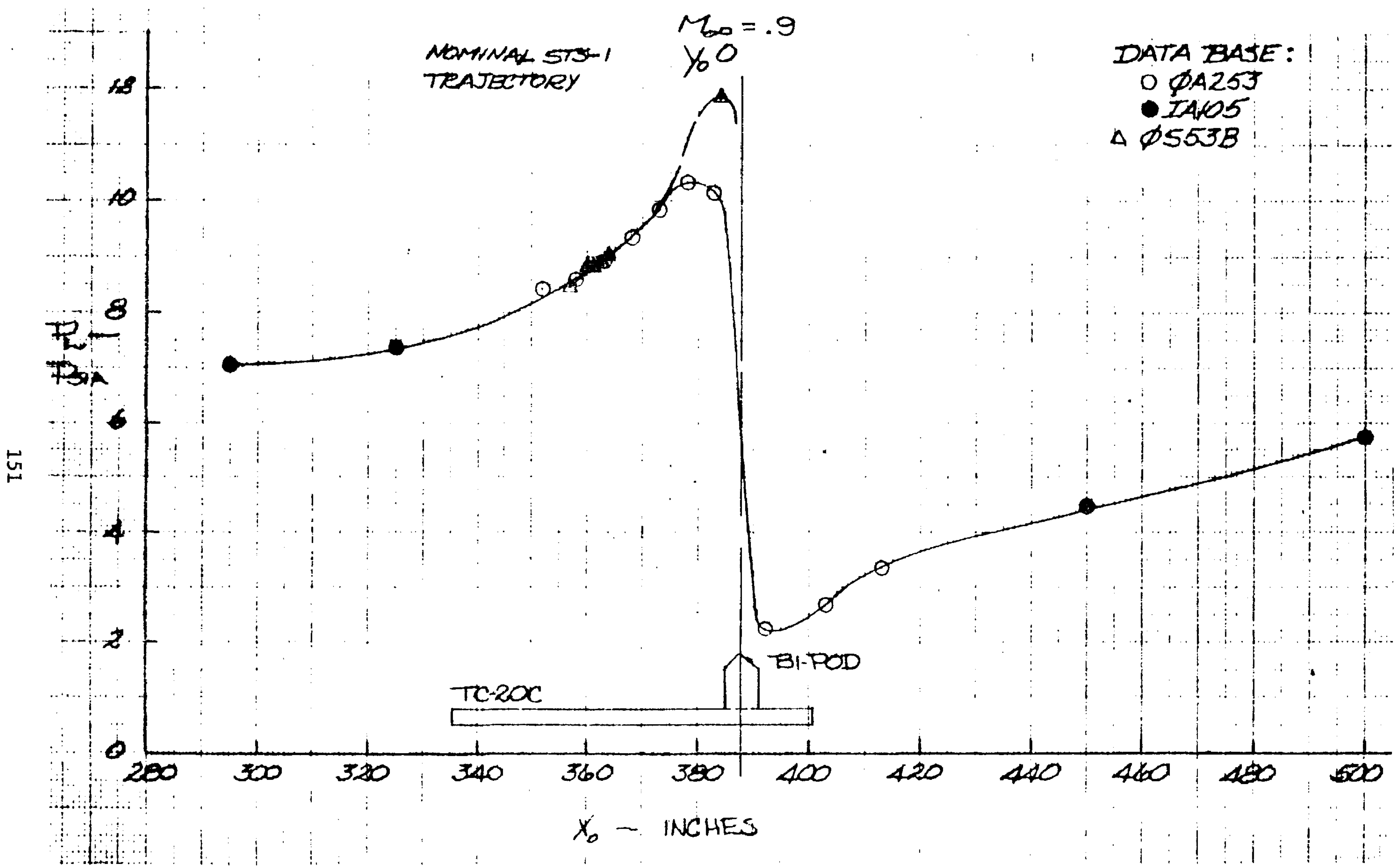


Figure 60q. CLOT Test Panel TC-20C, Pressure Distribution (M_∞ = 0.9)

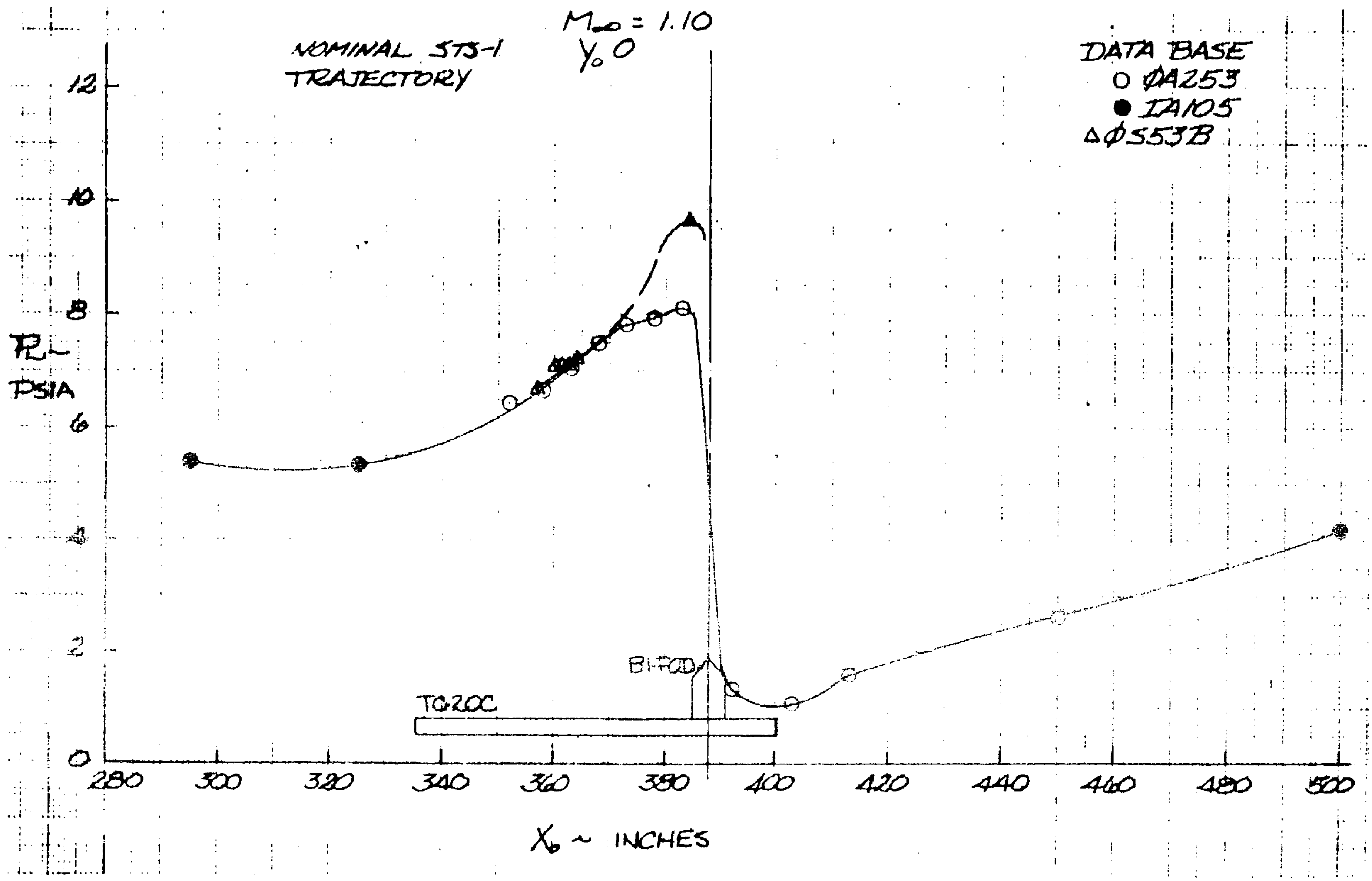


Figure 60r. CLOT Test Panel TC-20C, Pressure Distribution (M_∞ = 1.10)

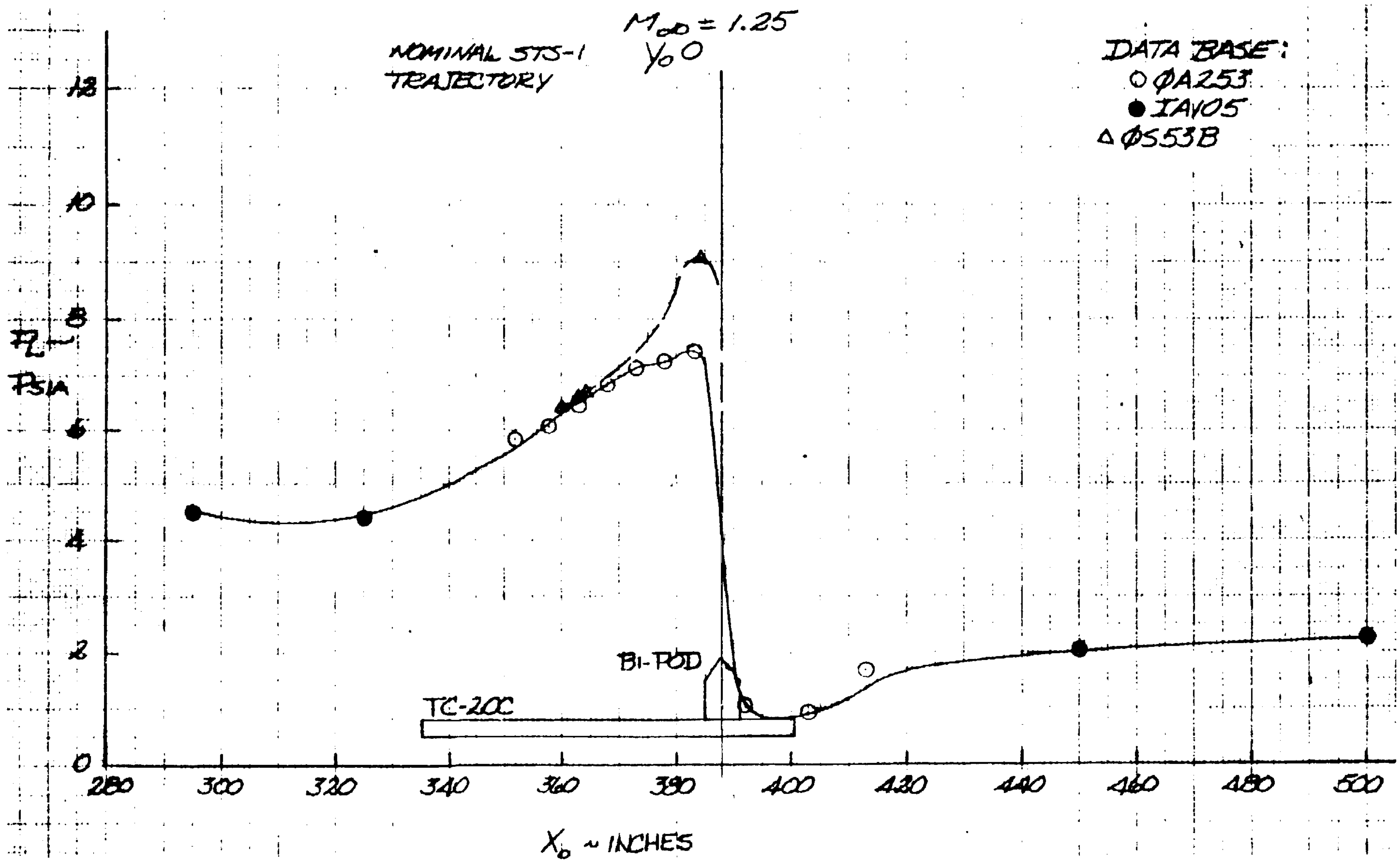


Figure 60s. CLOT Test Panel TC-20C, Pressure Distribution (M_∞ = 1.25)

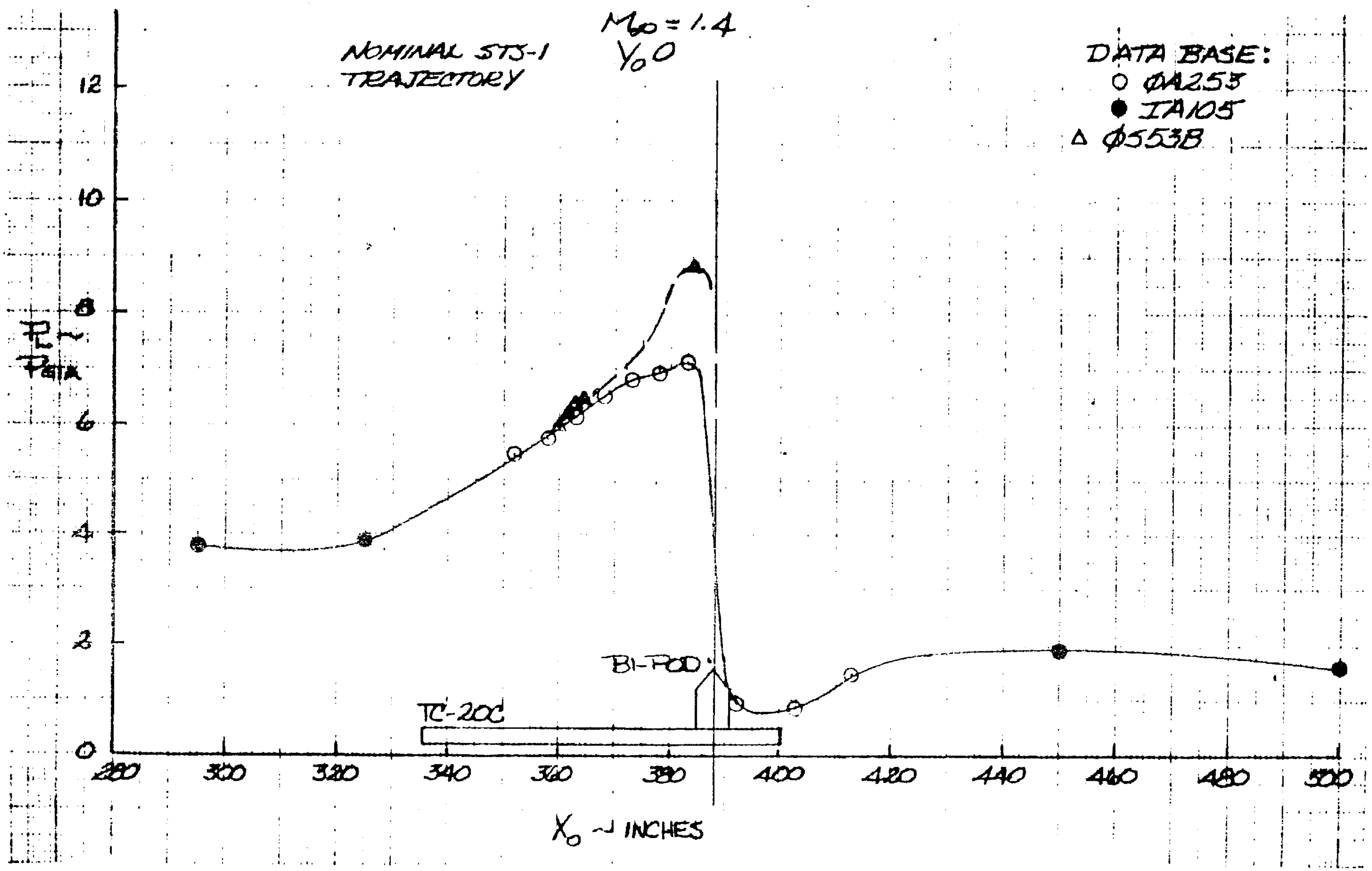


Figure 60t. CLOT Test Panel TC-20C, Pressure Distribution (M_∞ = 1.4)

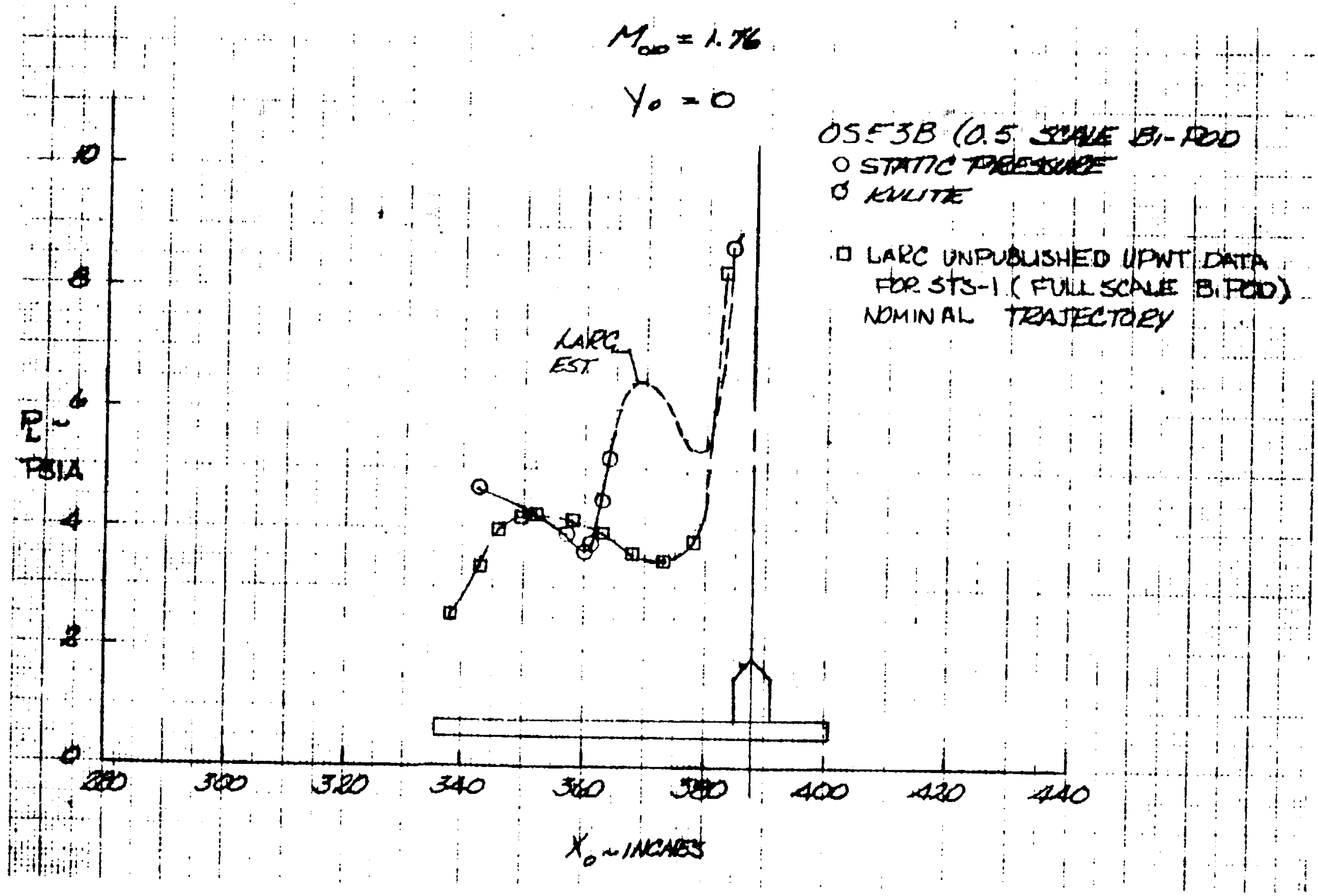


Figure 60u. CLOT Test Panel TC-20C, Pressure Distribution ($M_\infty = 1.76$)

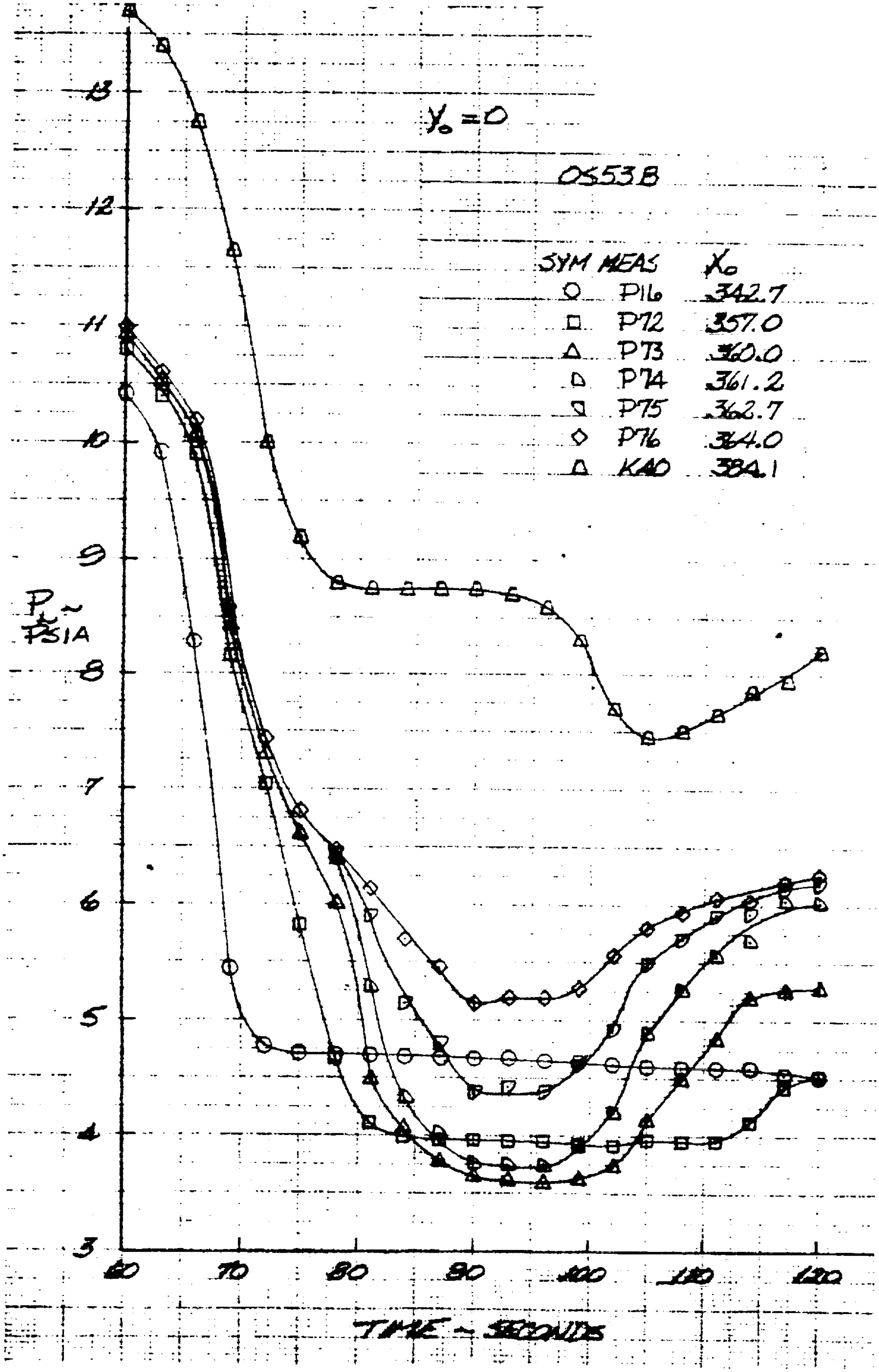


Figure 60v. CLOT Test Panel TC-20C, Panel Centerline Pressure Histories

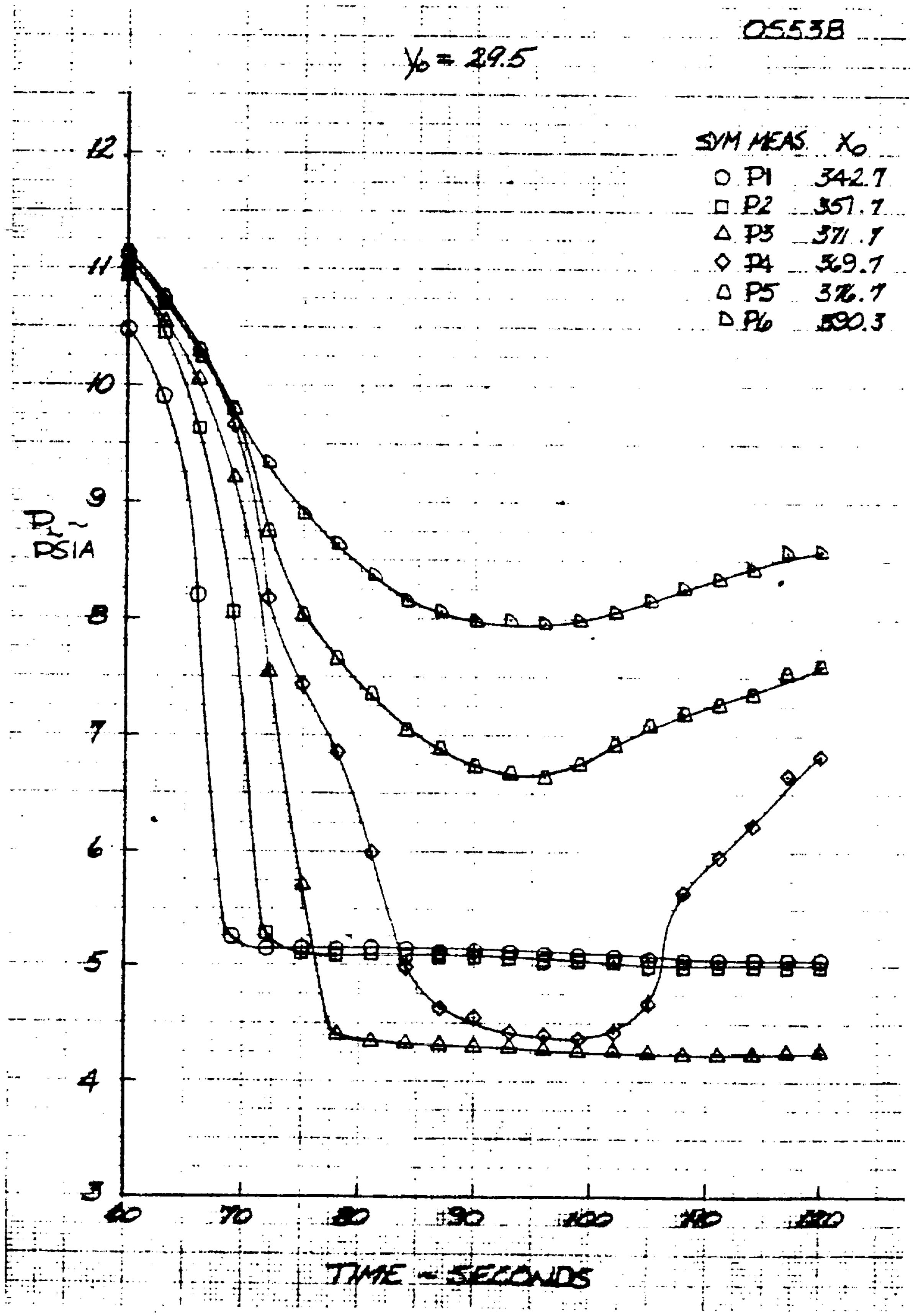


Figure 60w. CLOT Test Panel TC-20C, Panel Edge Pressure Histories

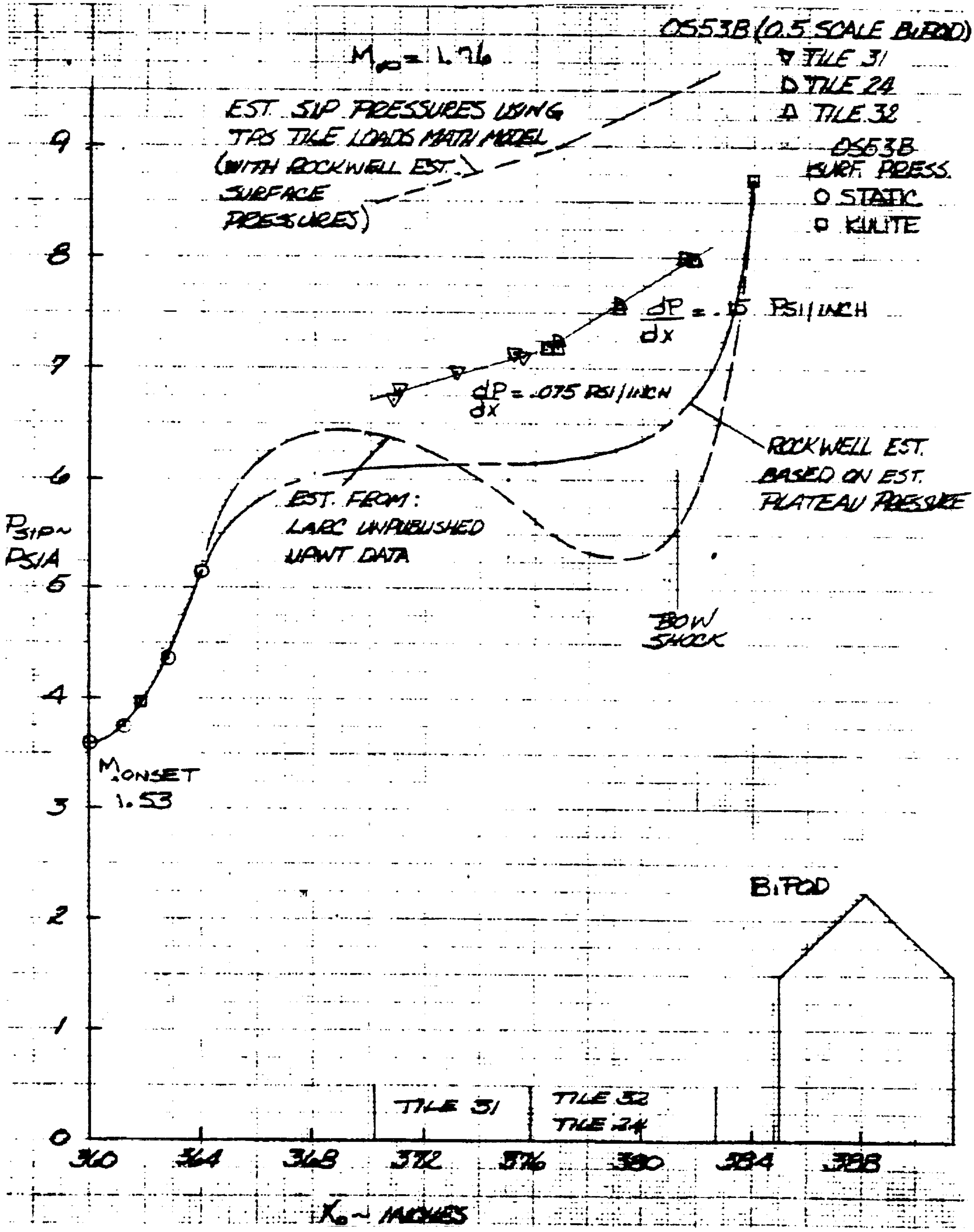
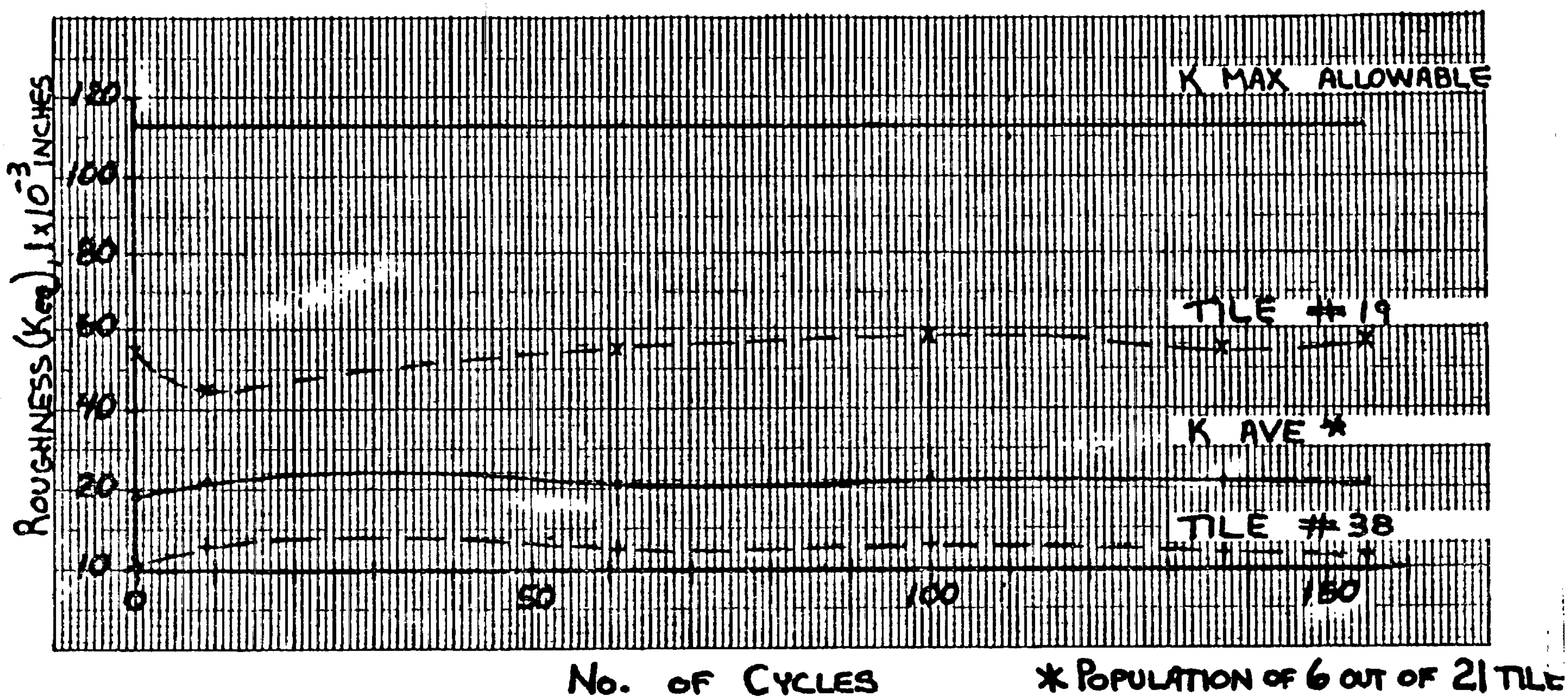


Figure 60x. CLOT Test Panel TC-20C, SIP Pressures for STS-1 Simulation @ Maximum ΔP Bow Shock Conditions



<u>CONCLUSIONS</u>

- K_{AVE} REMAINS ESSENTIALLY CONSTANT
- K_{MAX} WELL BELOW MAX ALLOWABLE ROUGHNESS

Figure 60y. CLOT Test Panel TC-20C, Surface ROUGHNESS Comparison

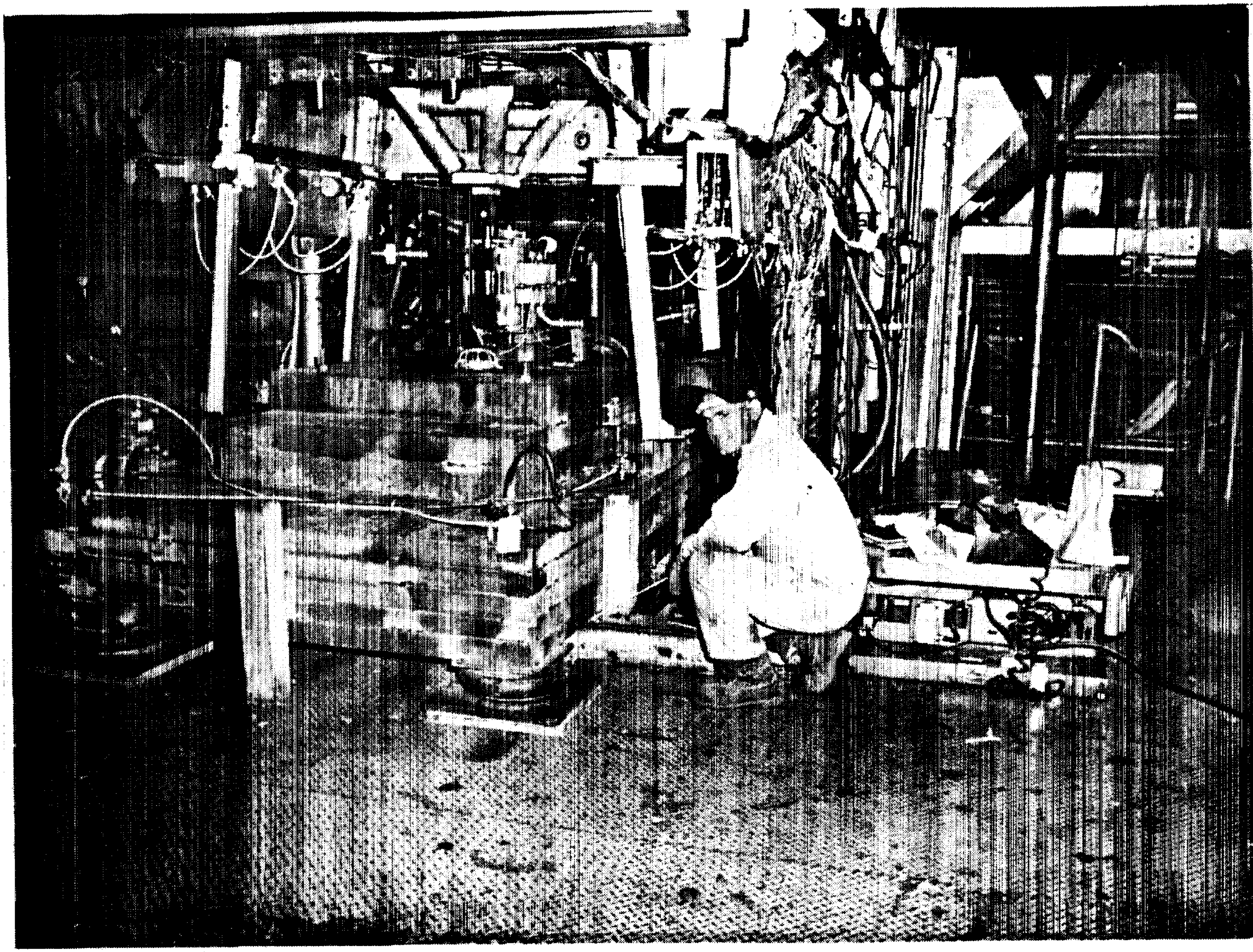


Figure 61a. CLOT - Aft Bipod Tile Acreage - Test Configuration 20A
Hydraulic Tile Panel Shaker System

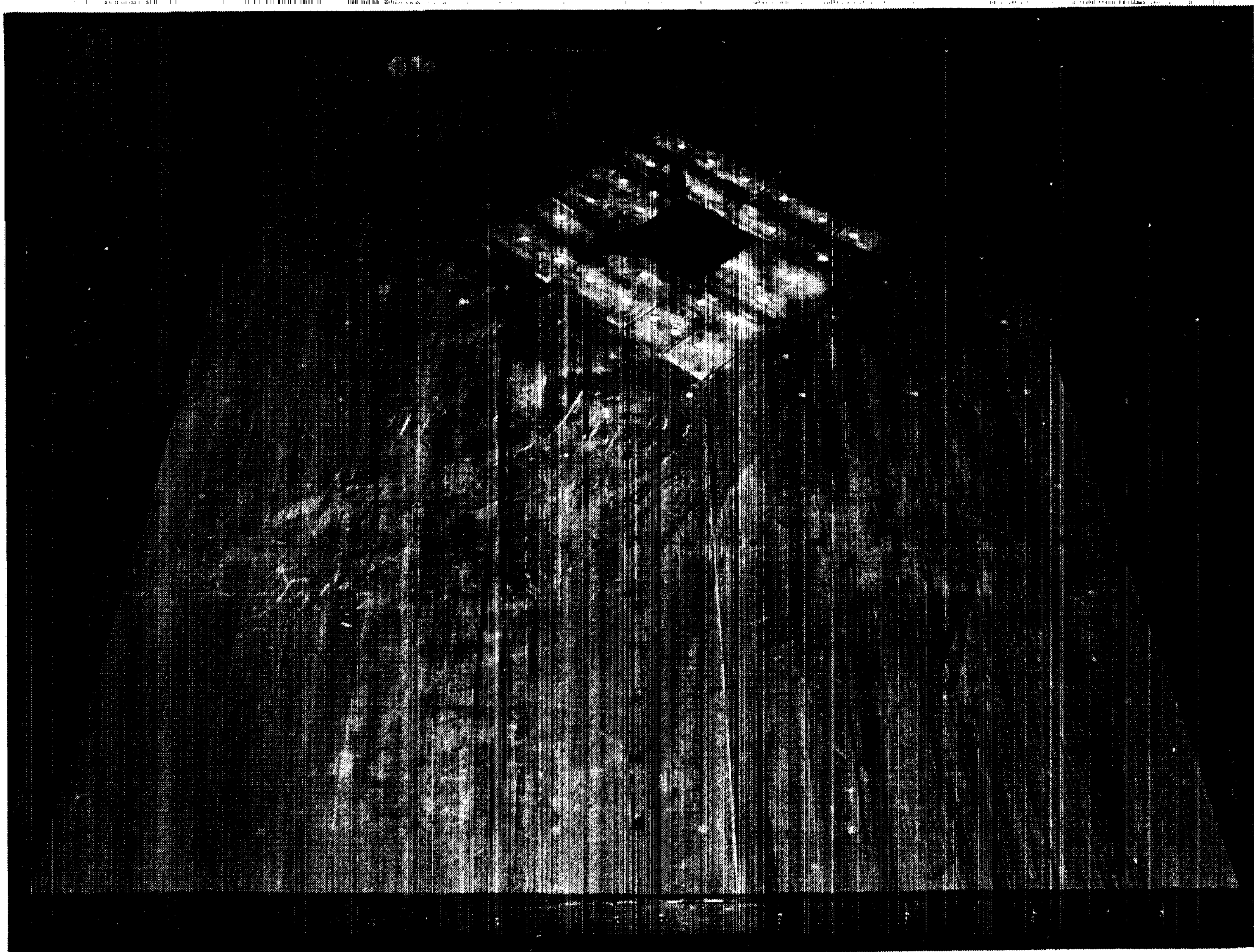


Figure 61b. CLOT - Aft Bipod Tile Acreage - Test Configuration 20A
General Arrangement in Test Facility (Pre Cal Panel)

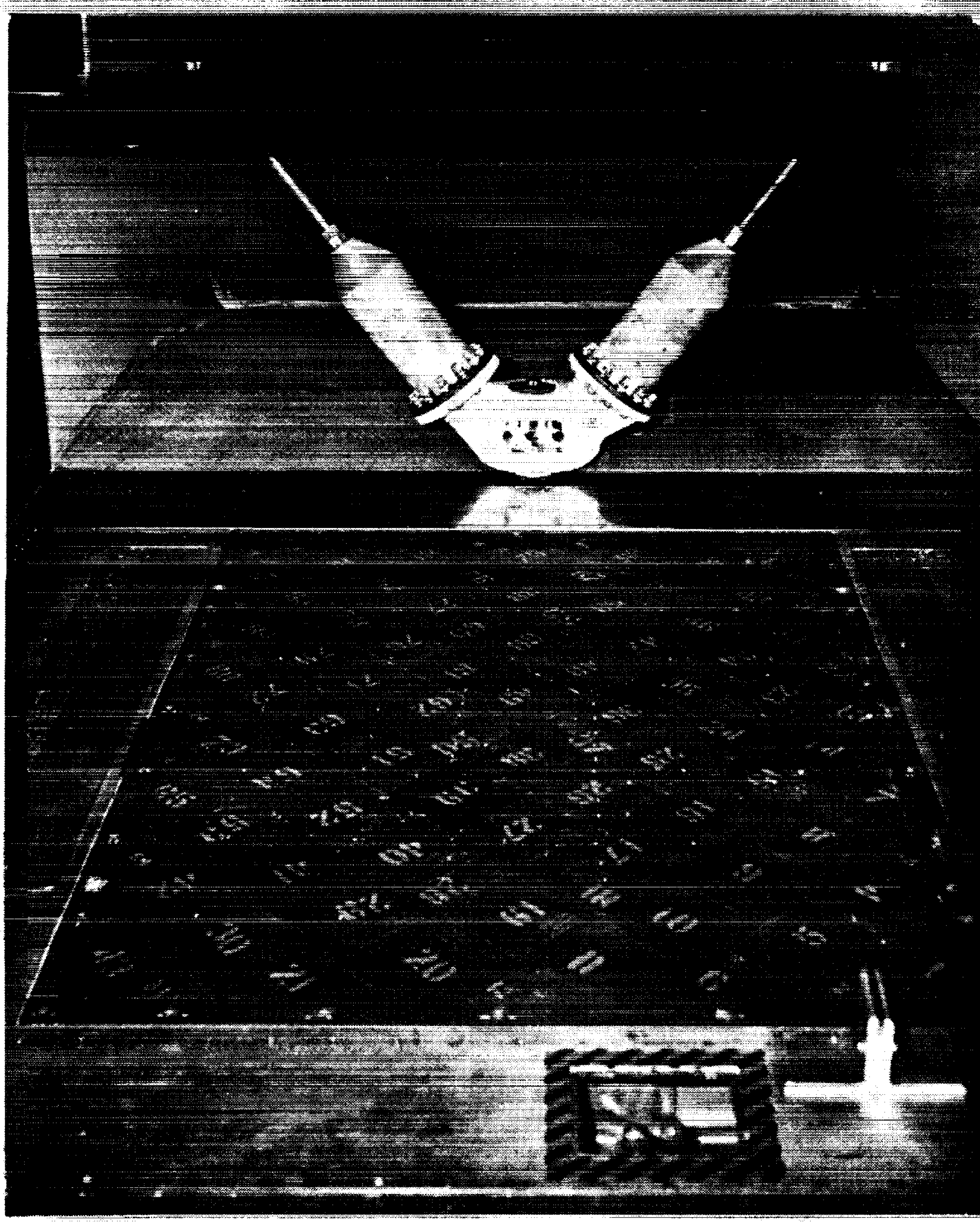


Figure 61c. CLOT - Aft Bipod Tile Acreage - Test Configuration 20A
General Arrangement in Test Facility (Calibration Panel)

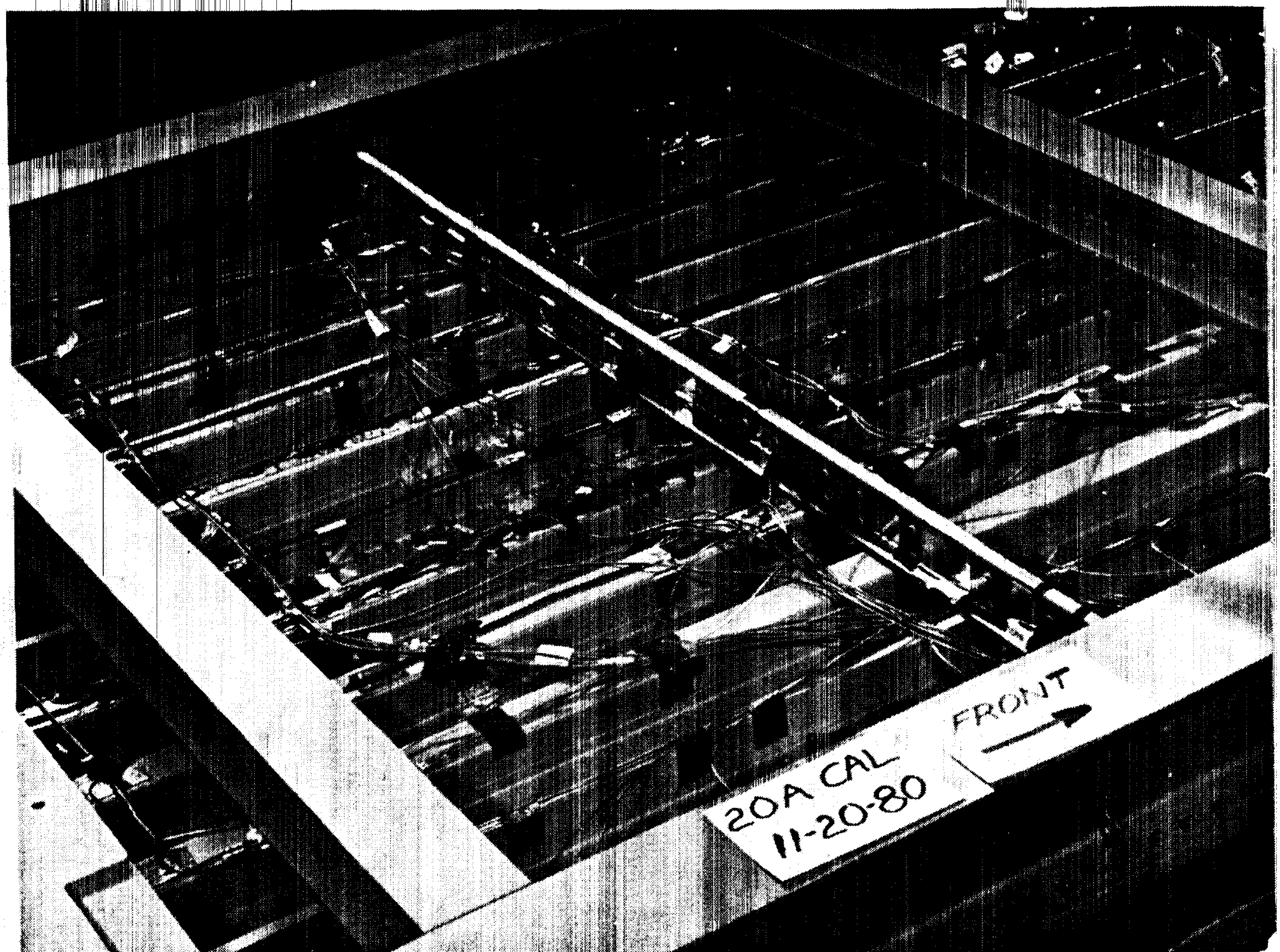


Figure 61d. CLOT - Aft Bipod Tile Acreage - Test Configuration 20A Calibration Panel Substructure Arrangement

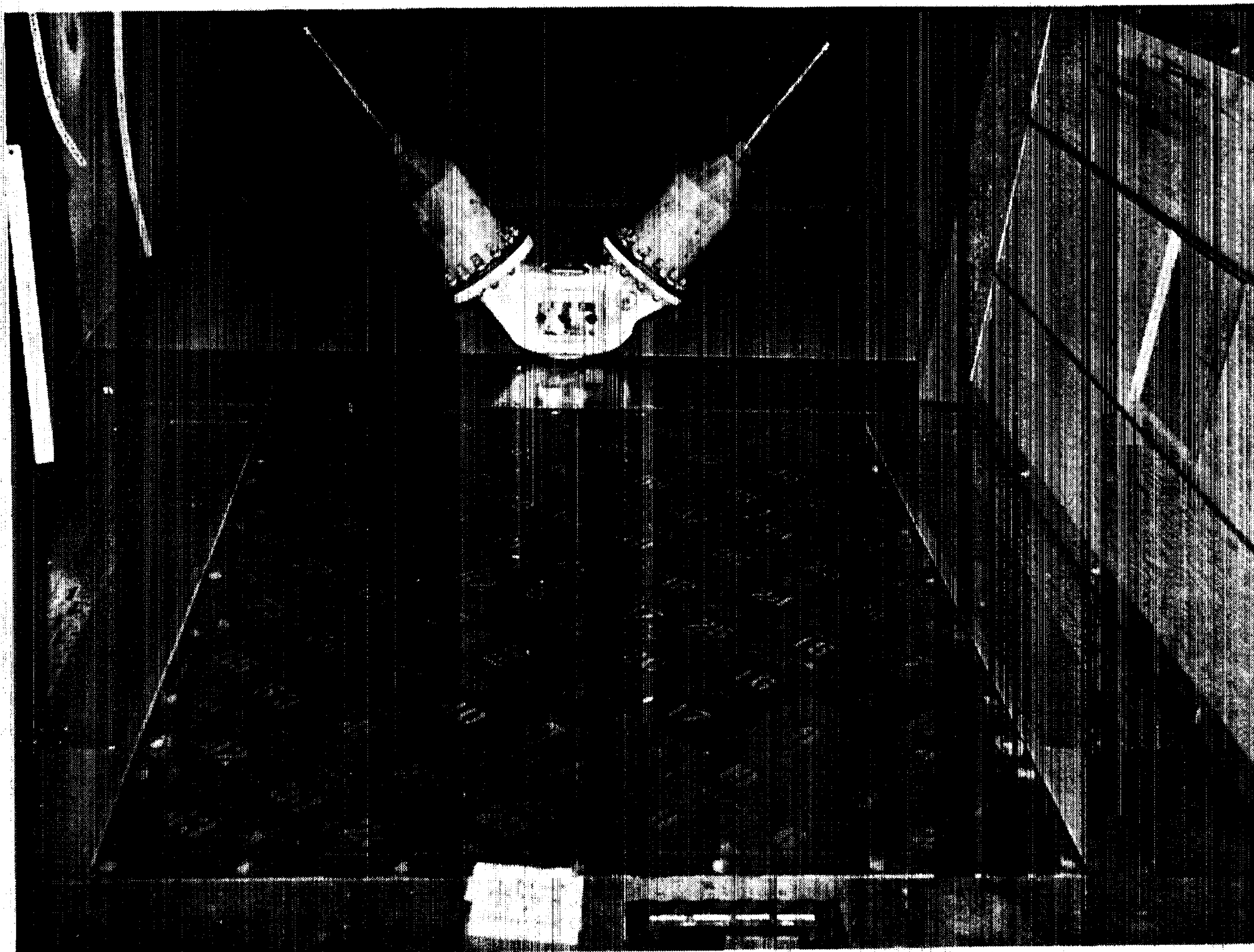


Figure 61e. CLOT - Aft Bipod Tile Acreage - Test Configuration 20A General Arrangement in Test Facility (Test Panel)

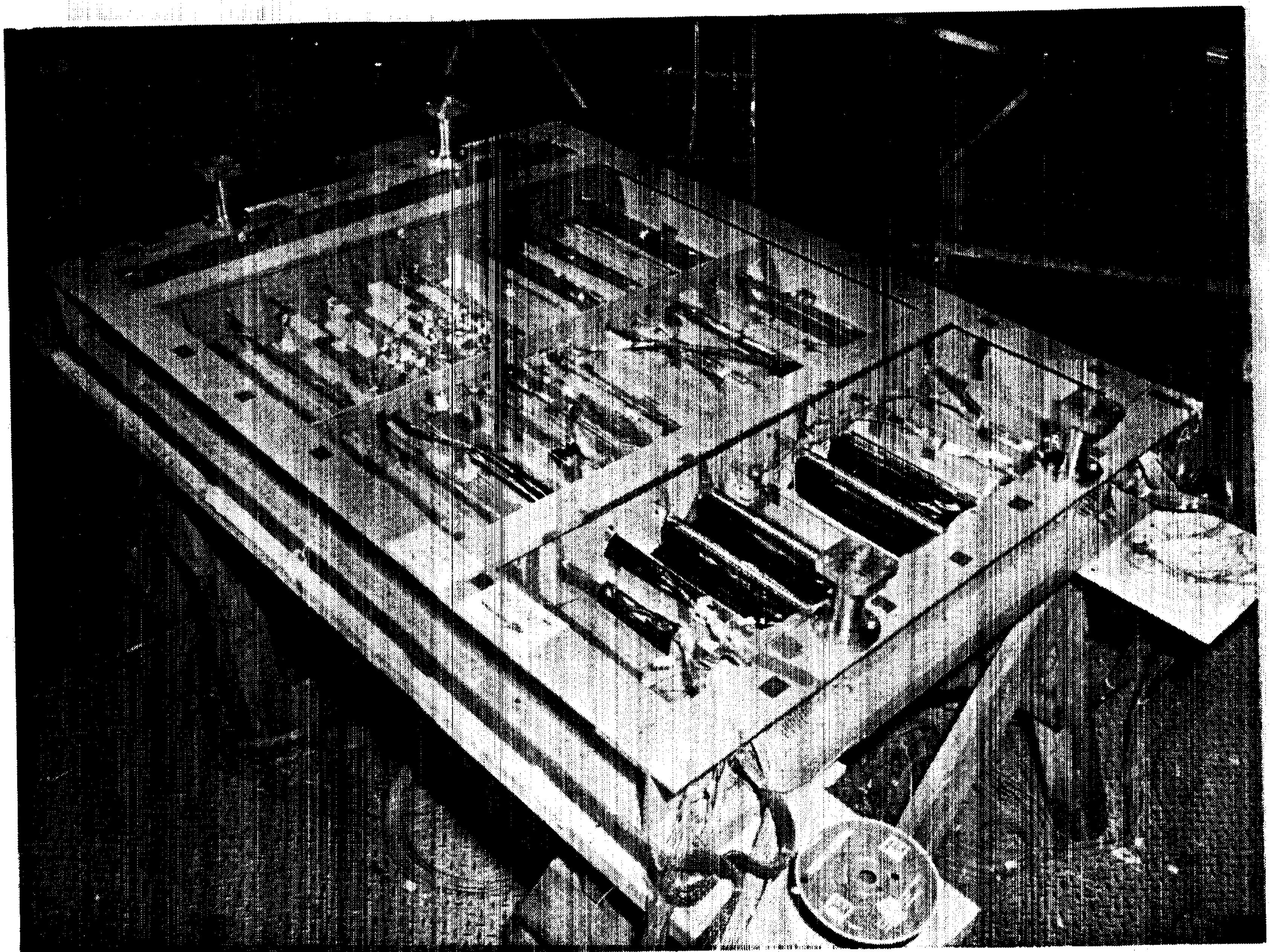


Figure 61f. CLOT - Aft Bipod Tile Acreage - Test Configuration 20A
Test Panel Substructure Arrangement

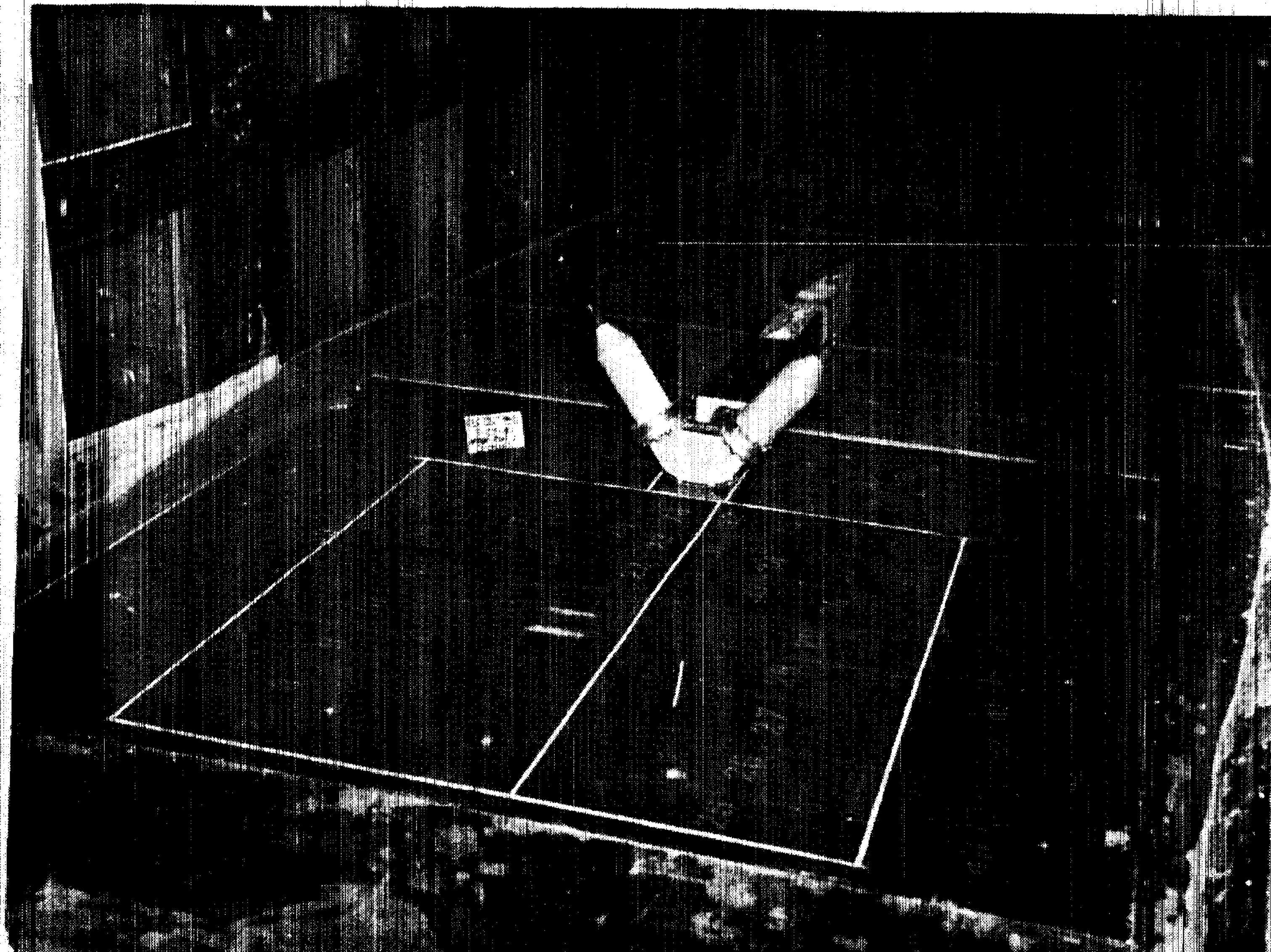


Figure 62a. CLOT - Nose Landing Gear Door - Test Configuration 20C
General Arrangement in Test Facility

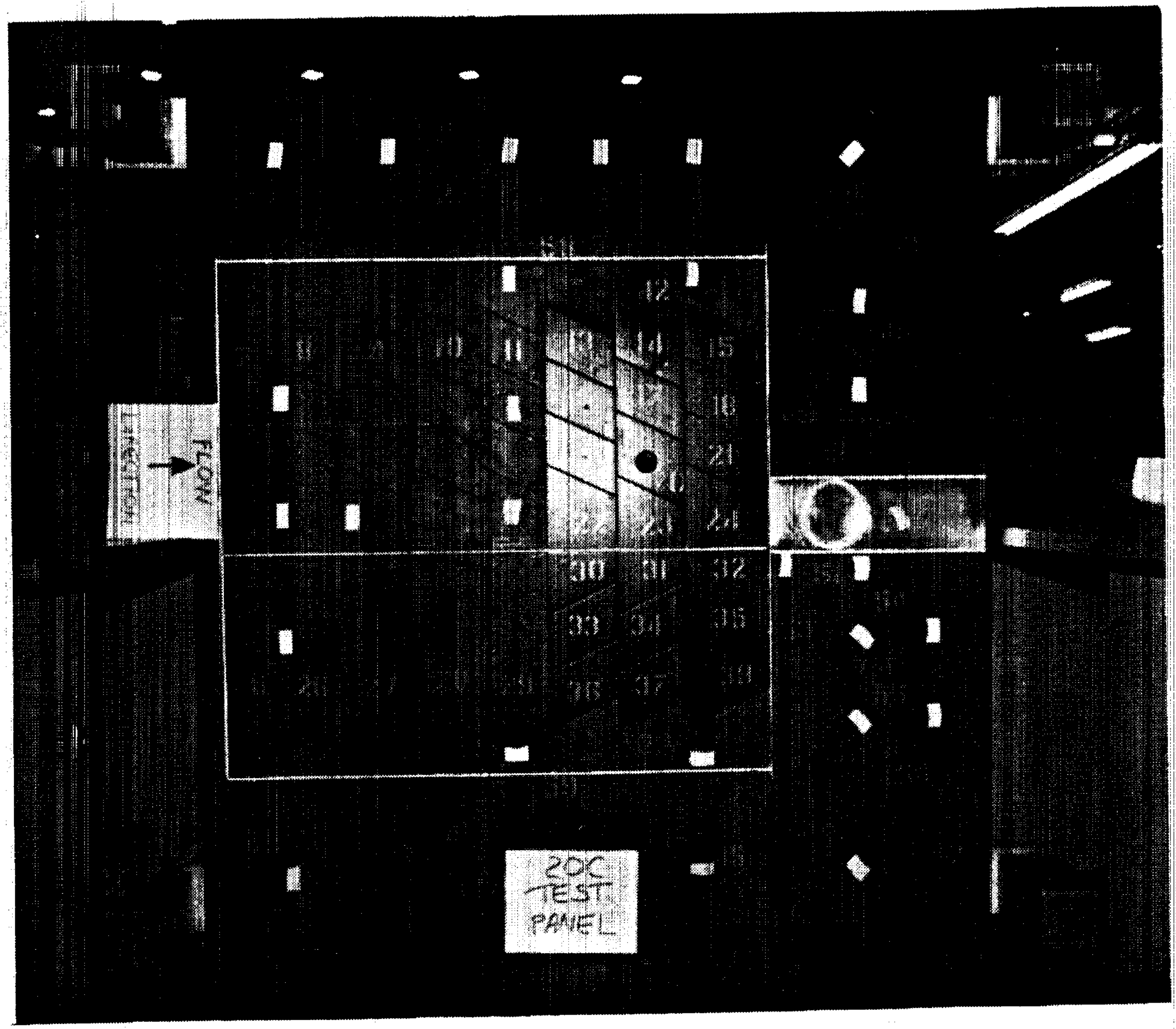


Figure 62b. CLOT - Nose Landing Gear Door - Test Configuration 20C Test Specimen General Arrangement

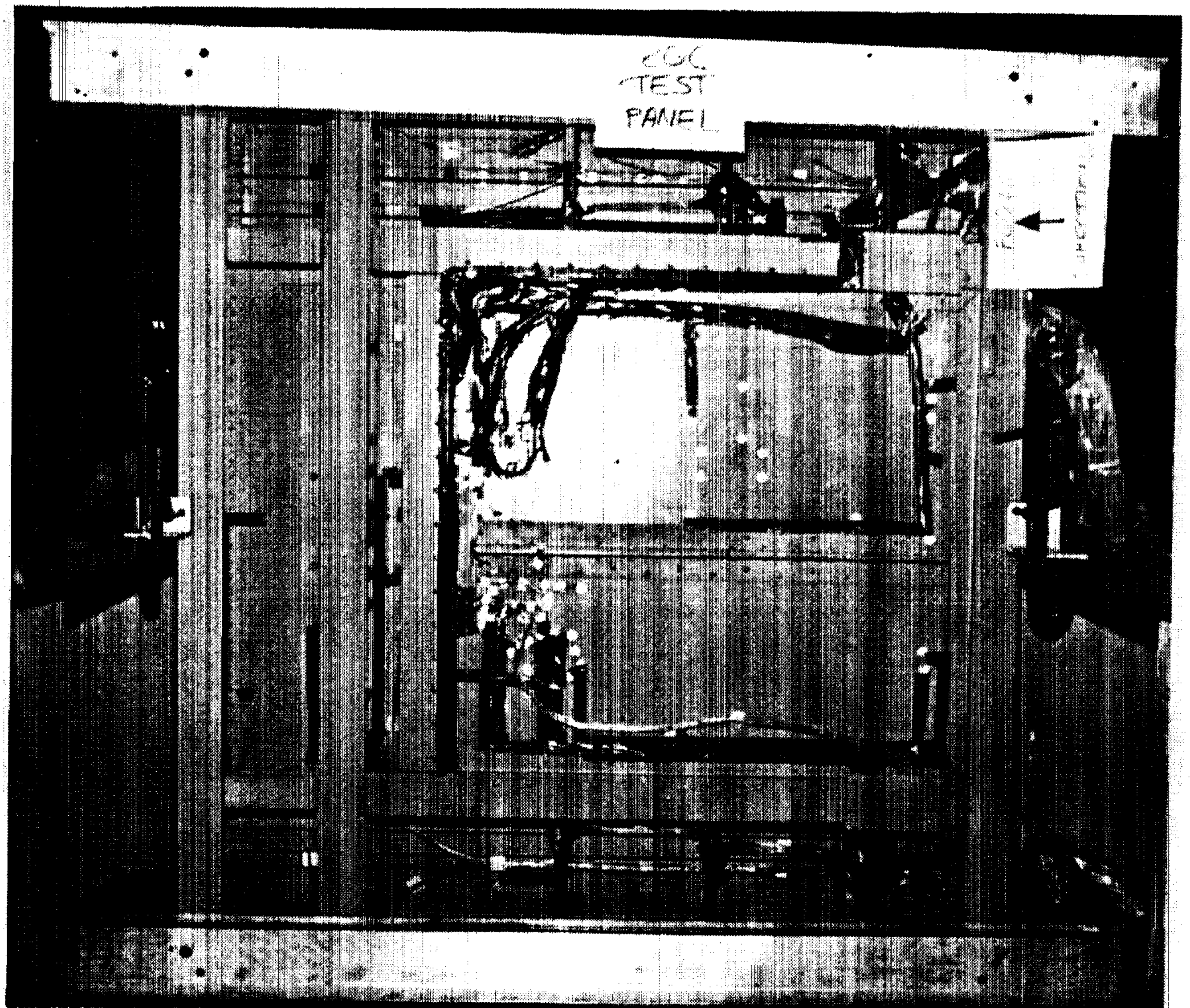


Figure 62c. CLOT - Nose Landing Gear Door - Test Configuration 20C Test Specimen Substructure Arrangement

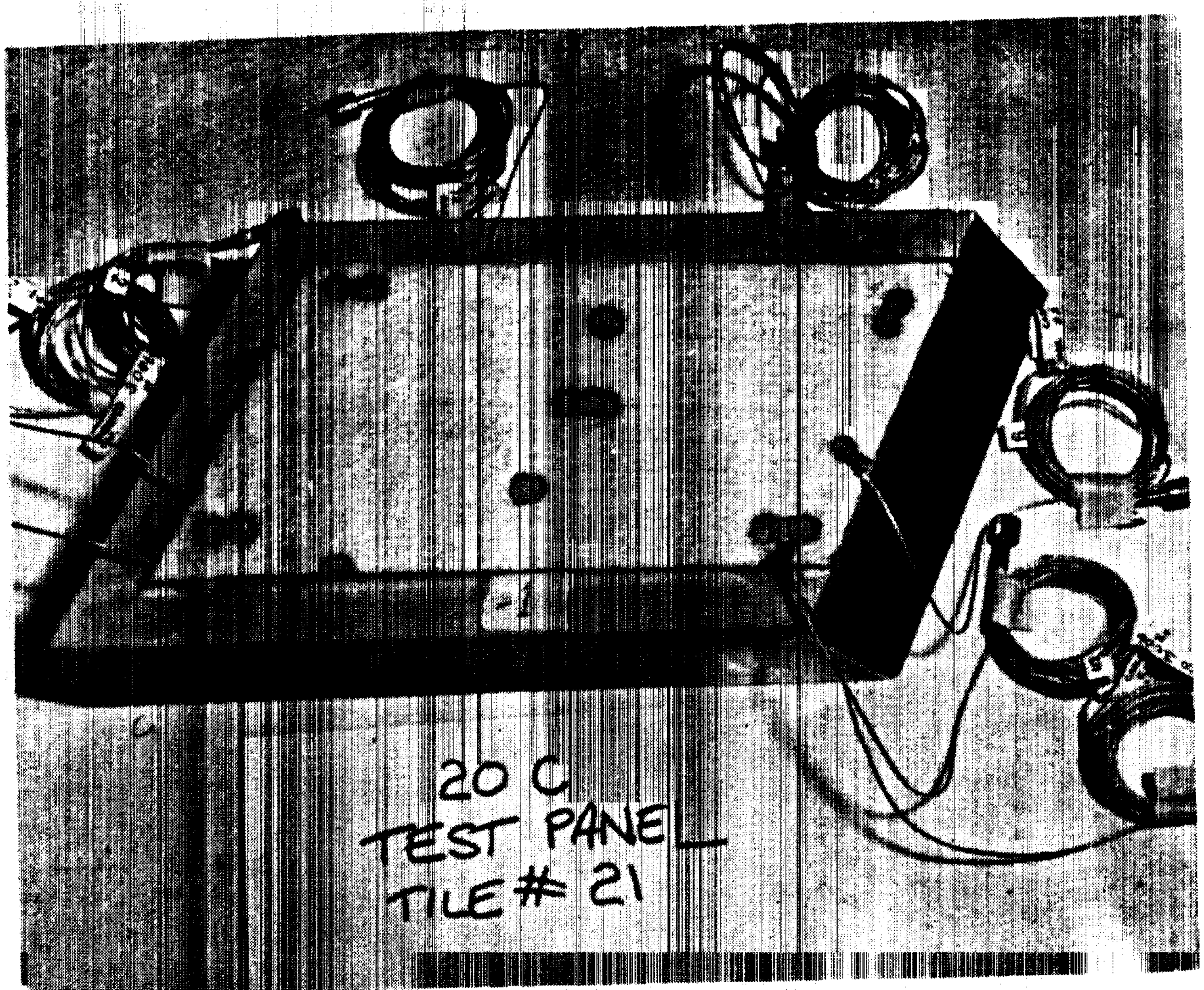


Figure 62d. CLOT - Nose Landing Gear Door - Test Configuration 20C Tile 21 Accelerometer Installation

Figure 62e. CLOT - Nose Landing Gear Door - Test Configuration 20C
Tile 21 Special Instrumentation Plate (COE)

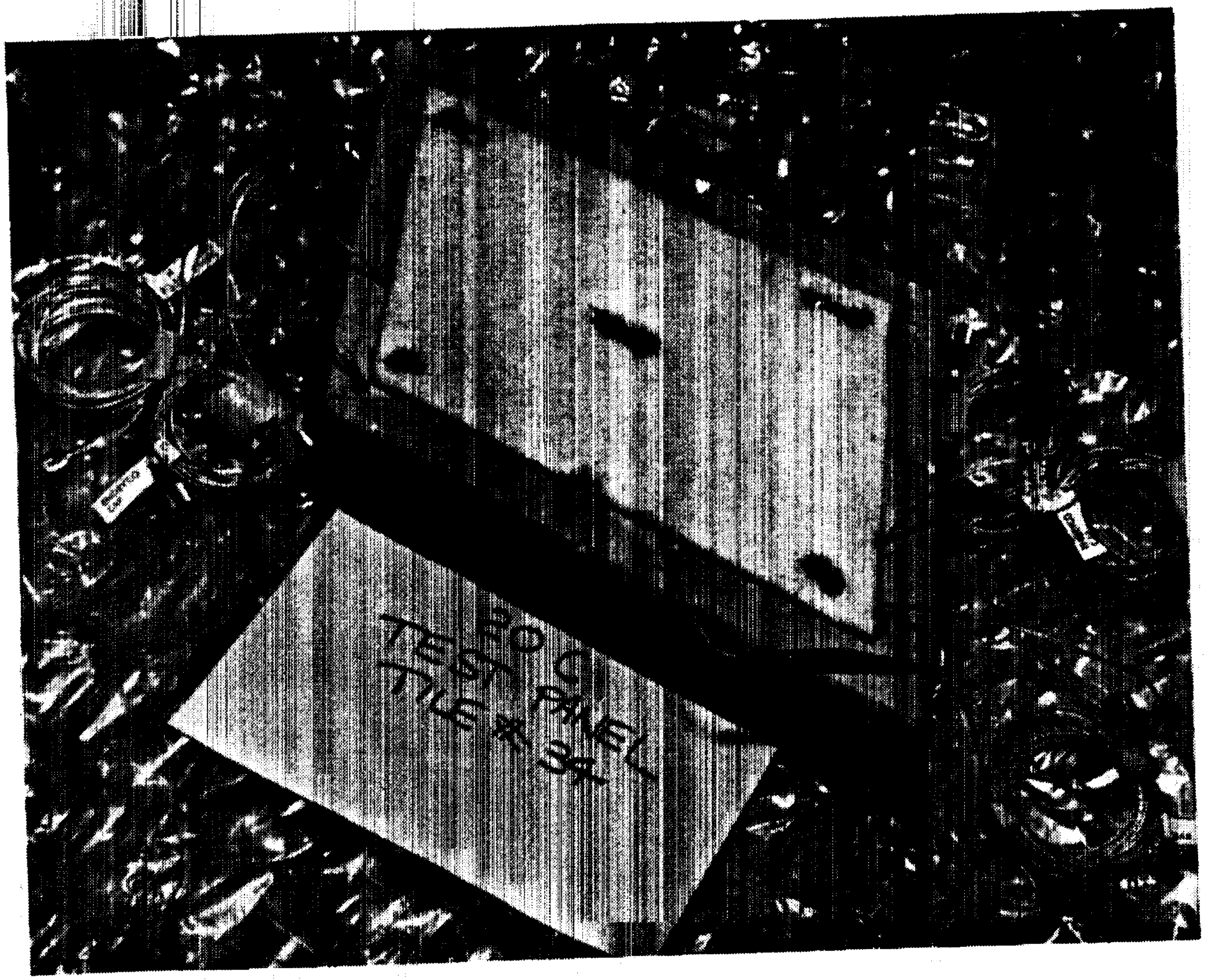


Figure 62f. CLOT - Nose Landing Gear Door - Test Configuration 20C
Tile 34 Accelerometer Installation

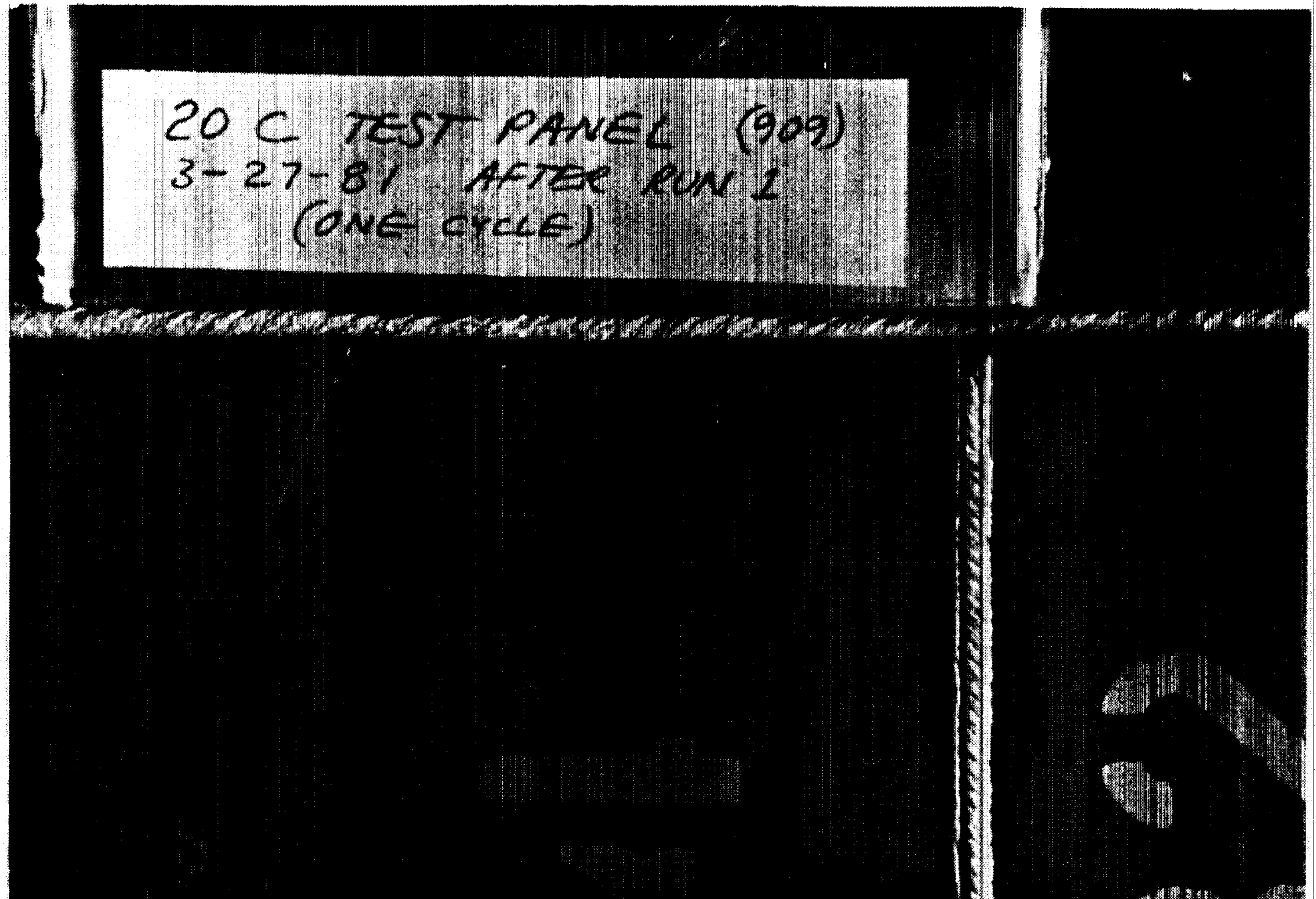


Figure 62g. CLOT - Nose Landing Gear Door - Test Configuration 20C
Post Run 1 (One Cycle) Thermal Barrier "Fuzzing"

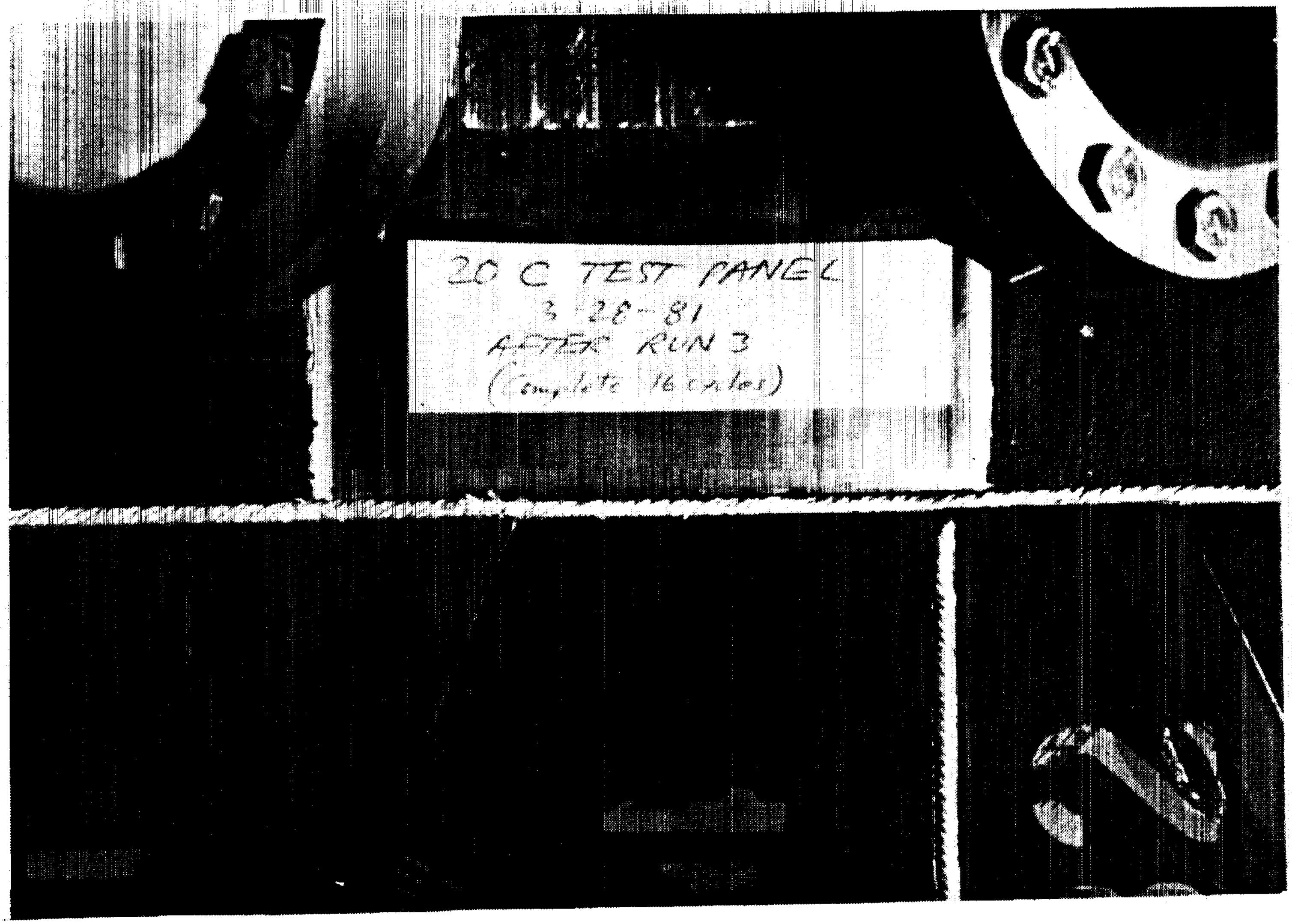


Figure 62h. CLQT - Nose Landing Gear Door - Test Configuration 20C Post Run 3 (16 Cycles) Thermal Barrier "Fuzzing"

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